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A Study of the Vegetation in the Upland Forest of St. John's Abbey and University, Collegeville, Minnesota

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A STUDY OF THE VEGETATION IN THE UPLAND FOREST OF ST. JOHN'S ABBEY AND UNIVERSITY, COLLEGEVILLE, MINNESOTA.

by

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This thesis submitted by Lorraine Westrup Cofell in partial fulfillment of the requirements for the Degree of Master of Arts at St. Cloud State University is hereby approved by the final evaluation committee.

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A STUDY OF THE VEGETATION IN THE UPLAND FOREST OF ST. JOHN'S ABBEY AND UNIVERSITY, COLLEGEVILLE, MINNESOTA

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PROBLEM

Data were gathered in the upland, hardwood forest of St. John's Abbey and University to 1) determine the composition and stage of succession of the forest, 2) compare an area that had been clear-cut fifty years ago with areas that had never been clear-cut, and 3) discover differences in the occurrence of species on north and south slopes.

PROCEDURE

Twelve areas of 10 acres each were chosen throughout the upland forest. The point quarter method was used to gather data on the trees listing the species of trees, circumference, and distance from sample point. On multiple trees, the circumferences of all trunks of the clone were recorded. In each quarter, the nearest shrub and sapling were also listed. The herbaceous plants present in a 1 x 1 meter quadrat at each sample point were recorded and the topography of the area noted.

The vegetational continuum index value of each study plot was determined on the basis of relative dominance, relative frequency, and relative density of the trees. Possible continuum index values could range from 300 for the most pioneer stand to 3000 for the most climax stand. The frequencies of saplings, shrubs, and herbaceous plants were calculated for each study plot.

FINDINGS

The continuum index values of the 12 plots ranged from 1470 for the plot that had been clear-cut 50 years ago to 2274 for the most climax area. Seventeen species of trees were present in the upland forest. Of these sugar maple was dominant in the four plots with highest continuum index values; red oak was dominant in the eight plots of lowest continuum index values. Bur oak saplings had greater frequencies in plots of lowest continuum index values. Sugar maple saplings had highest frequencies in plots of highest continuum index values. Some species of shrubs, vines, and herbaceous plants showed similar patterns of correlation with the continuum index.

In the plot that had been clear-cut in 1926 many of the trees had multiple trunks sprouted from stumps. The continuum index value of that plot increased slightly when dominance was based on the total basal area of all the trunks in a clone. The trunk density was twice that of any other plot but the average trunk size was much smaller.

Definite differences were noted in frequencies of species on north and south slopes. Bur oak was not found on north slopes. Birch, which occurs here in the southern limits of its natural range, had a frequency three times greater on north slopes than on south slopes. Red oak, red maple, sugar maple, basswood, trembling aspen, and green ash were present more frequently on northern slopes. Ironwood, large-toothed aspen, American elm, and black cherry had greater frequencies on southern slopes. Understory plants also showed differences in frequency according to slope.

DISCUSSION

St. John's Forest has plant species typical of several types of forest communities with species typical of southern dry mesic forest occurring most frequently. Succession appears to be progressing from dry to more mesic conditions. Variations are apparent throughout the forest. These variations could have been caused by 1) ground fires in some areas which have acted as retrogressive agents in forest succession, 2) a history of selective and clear-cutting, and 3) a topography which includes fairly level areas, steep hillsides, and areas relatively protected from fires by lakes and swamps.

July 14, 1977
Month Year

Approved by Research Committee:

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table		Page

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

Purpose of Study

The purposes of this study were 1) to determine the composition and the stage of succession of the upland forest of St. John's Abbey and University, 2) to compare an area of the forest that had been clear-cut fifty years ago with areas that had never been clear-cut, and 3) to compare vegetation present on north slopes with that present on south slopes of the forest.

No such study has been done of St. John's forest. This study contributes to the data available on the vegetation of St. John's forest and provides a record which may be useful in determining future changes in the forest.

Description of the Area

St. John's Abbey and University are located in central Minnesota in east central Stearns County about fourteen miles northwest of St. Cloud. It is at the junction of and has acreage in four townships: Avon, Collegeville, St. Joseph, and St. Wendel.

St. John's owns about 2,900 acres of land, and of that about 1,630 acres are deciduous forest. Another 120 acres are conifer plantations (Zirbes, 1969). The deciduous forest is predominately red oak and sugar maple. The area is a state game refuge and warning signs along the forest edge proclaim it a Wildlife Sanctuary which unauthorized vehicles are forbidden to enter.

Minnesota's history of glaciation is evident here. The St. John's land is on the St. Croix terminal moraine and is very hilly with many little ponds and marshes. Cultivated land in the area shows an abundance of stones. The SCS Soil Map of Stearns County, 1973, shows the soil to be of the Emmert-Flak association described as "the most picturesque and distinctive in the county. It occupies rugged hills, steep slopes, and marshy depressions in the vicinity of Collegeville and Avon in the east central part of the county." (See Figure 1) Schwartz (1954) said, "The red drift of the St. Croix moraine is exceptionally stony throughout the area. Cobblestones and pebbles as well as boulders abound on the surface, and local road cuts are thickly set with them." Elevation ranges from 1,100 to 1,240 feet (U.S. Geological Survey, 1965).

Several lakes are on the St. John's property; the largest is Lake Sagatagan covering about 360 acres. A number of marshy ponds, a few of which are formed by simple man-made dams, support an abundance of waterfowl.

Climate

The climate in central Minnesota is typically continental with a tendency to extremes in all climatic features, including wide variations in temperature. Most of the precipitation occurs during the summer, and is normally sufficient for farm and garden crops (Hoode, 1941). Storms producing hail, tornadoes, and freezing rain do occasionally cause damage. The area lies along the northern edge of the region of maximum tornado frequency. In 1894, when several tornadoes struck

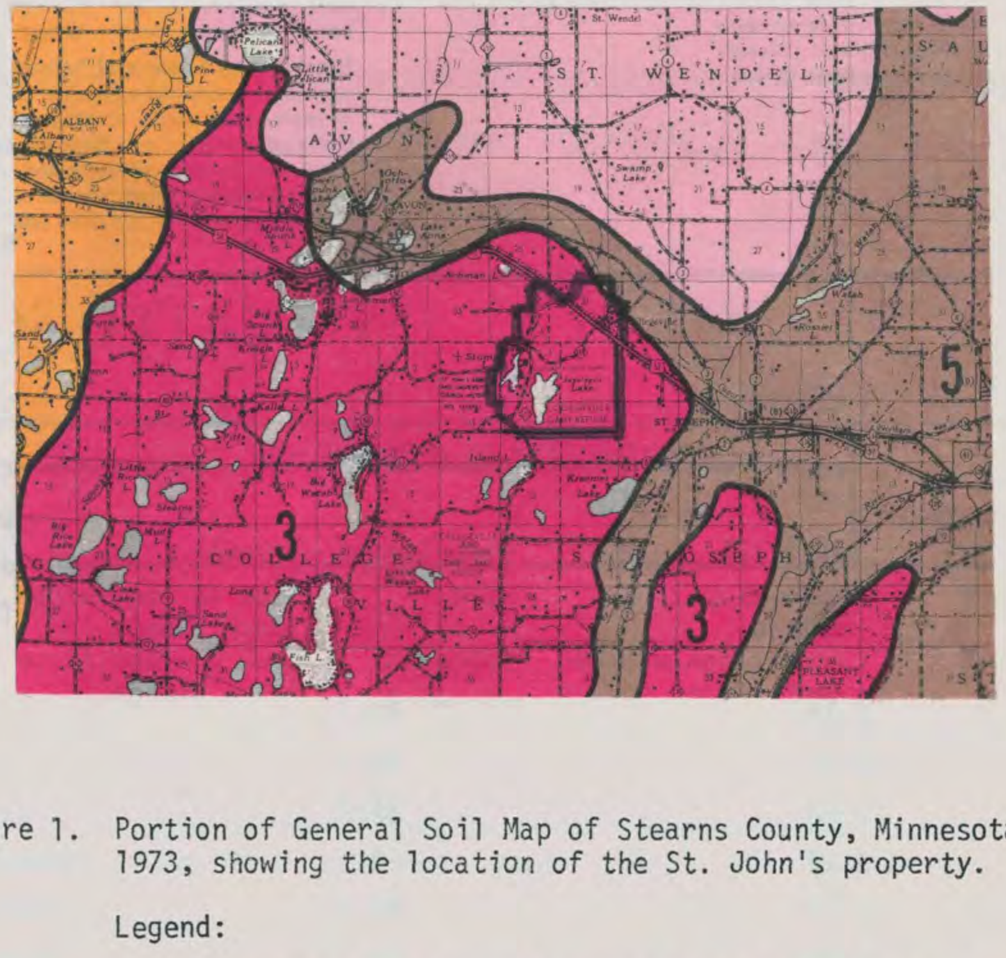

Figure 1. Portion of General Soil Map of Stearns County, Minnesota, 1973, showing the location of the St. John's property.

Legend:

Description of area 3, the Emmert-Flak Association: light colored, well and excessively drained, rolling and hilly soils formed in gravelly, sandy drift and sandy loam glacial till.

Description of area 5, the Esherville-Hubbard Association: dark colored, somewhat excessive to excessively drained, nearly level and undulating soils formed in loamy and sandy outwash materials.

central Minnesota, St. John's was severely hit. Most of the buildings were damaged; some were destroyed. Trees around the Abbey were "broken off like so many matches" (Barry, 1956).

Precipitation and temperature are similar to that in St. Cloud, 14 miles away. St. John's kept weather data, but no compiled records were available. The following table shows the mean precipitation and temperature based on information from the U.S. Weather Bureau in St. Cloud as reported from 1894 to 1974 (NOAA, 1974).

Table 1. Mean Precipitation and Mean Temperature of St. Cloud, Minnesota.

	Mean Precipitation (inches)	Mean Temperature (°F)
January	0.75	9.4
February	0.71	13.4
March	1.25	27.1
April	2.13	43.8
May	3.52	55.9
June	4.35	65.5
July	3.46	71.0
August	3.48	68.6
September	2.95	59.2
October	1.98	47.4
November	1.20	30.6
December	0.65	16.3
Annual	26.43 Total	42.3 Average

History of St. John's Property

St. John's Abbey and University began as a log building on the banks of the Mississippi River just south of St. Cloud, Minnesota.

Five Benedictine priests and brothers, originally from Bavaria and then from St. Vincent's Abbey in Pennsylvania, arrived at St. Cloud in the spring of 1856. Here they began their work as missionaries and educators in Minnesota, receiving a charter from the Minnesota Territorial Legislature in 1857 (Barry, 1956).

Because the St. Cloud site lacked sufficient wood and pasture land, some of the monks were dissatisfied and wanted to look for land further west. In the summer of 1856 Rev. Bruno Reiss explored the land about four miles west of St. Joseph along the Watab River. The area was called "Indianbush" because it had recently been the hunting ground of the Sioux and Chippewa Indians. Descriptions of the area included references to dense underbrush, excellent timber, and beautiful meadows of wild hay which grew higher than their heads (Barry, 1956).

Rev. Reiss wrote of his explorations of Indianbush:

> A relative of Mr. J. H. Linnemann led me through the thickets along the banks of the Watab, and here it was, that I struck upon the splendid pastures of Sec. 31, irrigated by the northern branch of the Watab. The bush lying toward the south had been burnt by the Indians in the previous year. The land thus cleared might be turned into pasture. To the west, as far as my eye could reach, I could see nothing but dense forest. I concluded to make a detailed exploration of the country. ....
>
> Now I proceeded to inspect, mounting hills and climbing trees, to get a view of the surrounding country, and frequently consulting the compass and counting my steps lest I should not find my way back to St. Joseph. Despite its scorched hills, Section 31 pleased me, because it furnished water and meadows with fine grass. Now for timber, I went prospecting in Sec. 36 during the ensuing week, but with little success. Section 6 suited me better. On these expeditions my twill trousers and blouse were pitifully lacerated by the thorns and shrubbery, and blood trickled from my hands and feet. .... (Reiss, 1889).

The monks decided to claim the land, and erected shacks on each of the 360 acres as required by law. Father Reiss continued:

> For the sake of greater security we kept close to the township line and began cutting tamaracks for a small hut 16 x 20. Near by we had cleared a small space for a building. This clearing was a short distance south of the present Collegeville station. None of us ever imagined a railroad would be built in that vicinity so soon.......

The following year, in the course of surveying, the monks came upon a 360 acre lake which is now called Lake Sagatagan. This lake they also claimed, and on its north shore the present abbey and university now stand. In 1864, after years of difficulty in obtaining title to the property near St. Cloud, the monks abandoned that site to move to a small frame house near the present Collegeville station. By then some land had been cleared and put under cultivation. Two years later they moved to the north shore of Lake Sagatagan. Soon thereafter a dam was built across the North Fork of the Watab River to provide power for a saw mill and grist mill. This dam formed Stump Lake, sometimes called Little Watab Lake.

The railroad was built through Stearns county in 1872; Collegeville station opened in 1879. The old stage route to Breckenridge ran approximately where U.S. Highway 52 would later be located. As the area became more populated it became a "road", and in 1926 was paved with cement to become a "modern highway" (Hoffman, 1934). Highway 52 became a 4-lane highway in the early 1950's. In 1976 work began to make it part of U.S. Interstate 94. Each stage of highway development removed a bit of St. John's land from forest production.

The University grew rapidly in those early years. In 1875, 130 students were enrolled (Hoffman, 1907). With this growth also came increased needs for agricultural land and wood for fuel and lumber. Some forest was cleared for farming. Older members of the Benedictine community still recall watching on winter evenings the beautiful spans of horses returning with men and sleds after a day of cutting wood in the forest.

The tornado of June 1894 took down so many trees that it "left the surrounding country a bleak desert" (Hoffman, 1907). The replanting of the damaged areas of forest after this storm is largely credited to Father Adrian Schmitt. The peninsula near the present high school is named after him. Father Adrian was concerned about replanting the forest at St. John's, and he sought advice concerning his reforestation work from relatives who were governmental foresters in Baden's Schwartzwald. This consultation accounts for his decision to use evergreens rather than the native hardwoods. He started a nursery near Little Watab Lake which would supply thousands of evergreen seedlings for later plantings. The first pine and spruce plantings were around the University buildings and the high school. Father Adrian received recognition for his work from the State Department of Forestry. His concern for preserving the forest, though not necessarily the original forest, was the beginning of a tradition that continues at the abbey to the present day (Barry, 1956).

In recent years the abbey has selectively cut trees in the pine plantations where growth was too thick or trees were diseased or rotten. One such area is the pine plantation near the east entrance. This plantation is over 40 years old, and the trees are crowded and slowly dying. Cutting also was done in the area where trees would be lost to the construction of Interstate I-94 (Arden, 1974). Selective cutting produces denser undergrowth. The undergrowth in the pine plantations is typical of a deciduous forest, indicating that the plantations will eventually return to deciduous forest.

PROCEDURE

This study was limited to upland forest. However, several times random sample points fell near wet land because ponds occur frequently in the upland areas. Most of the field work was done during the summer of 1974. A small amount of follow-up work was done in the spring and summer of 1975.

Description of Study Areas

Twelve areas were chosen for study. These were well scattered throughout the upland forest areas and easy to locate on a map. A trail map from St. John's was used which had the same scale (1 inch = 660 feet) as an aerial photo obtained from the ASCS office. All of the study areas were hilly except Plot 3 which was relatively level. All areas showed at least some evidence of tree cutting. Figure 2 shows the location of the study areas.

Plot 1 contains barbed wire and an old concrete tank in a creek, indicating that at least part of this predominately red oak (*Quercus borealis*) section of forest was at one time pastured.

Plot 2 has steeply hilly terrain and is predominately sugar maple (*Acer saccharum*). It is near the ski hills and the old site of a maple syrup processing building, with trails through the area for collection of maple sap. There are some very large trees in this area; the largest tree sampled was a sugar maple with a diameter of 27.7 .

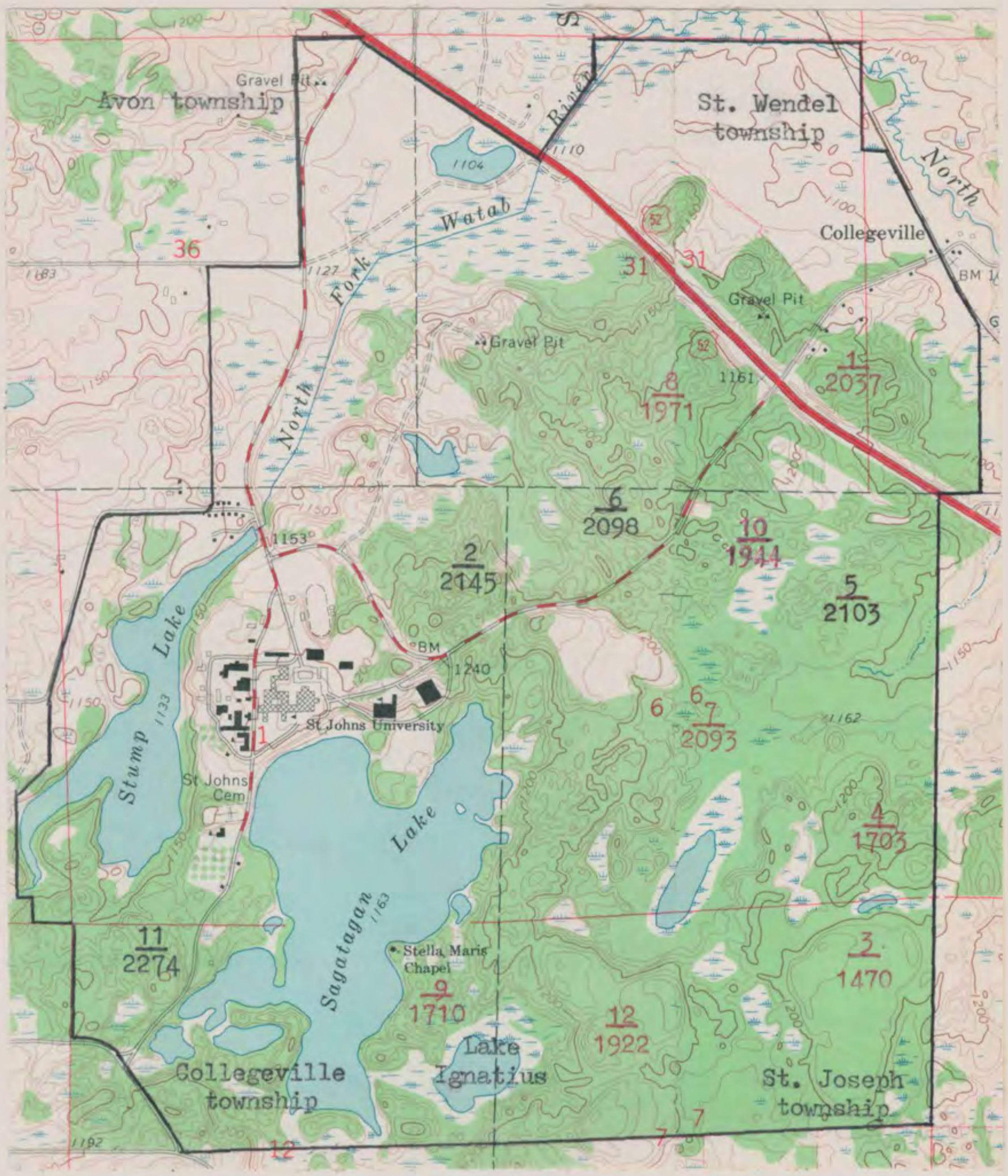

Figure 2. Map of St. John's Forest Showing Plot Numbers and Continuum Index Values.

Key: Red numbers - Red oak had highest Importance Value
Black numbers - Sugar maple had highest Importance Value

inches. Litter and weedy plants indicate disturbance caused by the area's proximity to the university.

Plot 3 is a relatively level area. It was chosen for study because it had been clear-cut for cultivation in 1926. It was never cultivated but was allowed to regrow to trees. A large number of trees have multiple trunks originating as sprouts from stumps, giving the area an appearance very different from the other areas studied.

Plot 4 is located near Plot 3, and was chosen for possible comparison with Plot 3. It is very remote from the university and seems relatively undisturbed. No trails or roads cross this area. Plates 1 and 2 show the difference in the appearance of Plots 3 and 4.

Plot 5 is an area where sugar maple sap was gathered. Tractor trails cut through the area and some sap collecting pails had been left on trees. There are a number of fallen and cut trees and many tree stumps.

Plot 6 contains a few small areas showing the multiple trunks characteristic of second-growth forest. There are some large open grown white oaks (*Quercus alba*) in the area.

Plot 7 is in the interior of the forest and contains several small ponds in which *Calla palustris* is present. Witch hazel is found in this plot only. Much of this area had been burned a few years before this study and charred branches, trunks, and stumps are still visible. Bark from some of the maples could be easily removed to reveal fungus growth. Sugar maple trees are very sensitive to fire. Curtis (1971) writes that the thin bark of the sugar maple is easily damaged by ground fires and cambial injury occurs even in trees showing little

Plate 1. View of Plot 3 Showing Multiple Trunks Characteristic of Second-growth Forest.

Plate 2. View of Plot 4 Showing Appearance of Forest that has Never Been Clear-cut.

external charring.

Plot 8 is located between pine plantations and areas that had once been cleared. The plot contains a pond which was dry in August, a forest road, and an old fence.

Plot 9 is between Lake Sagatagan and Lake Ignatius and has very hilly terrain.

Plot 10 is between County Road 159 and a low marshy area to the east. An old road which once connected the campus with the highway passes through this area.

Plot 11 is between Lake Sagatagan and Stump Lake. It contains many large basswood (*Tilia americana*) and elm (*Ulmus americana*) trees as well as sugar maples.

Plot 12 is in the remote southern part of St. John's forest where red oak is prominent.

Field Methods

The equipment used was a magnetic compass, a fifty foot measuring tape, a bamboo stake, four one-meter sticks, a trail map from St. John's University, an aerial photo from the Agricultural Stabilization and Conservation Service, notebooks, pencils, and insect repellant.

In each study area a starting point was chosen as representative of a more or less homogeneous area. From this starting point, random sample points were established along east-west or north-south compass lines, depending upon which best suited the area. Sample points were taken every twenty-five steps, the average distance between the points being about seventy-five feet or about every three millimeters on the trail map. Additional compass lines were 50 steps or about 150 feet apart. Forty points were sampled in each area. Each study area was approximately 10 acres.

The point-quarter method was used to gather data on the trees (Cottom and Curtis, 1956). The bamboo stake was set at the sample point and two meter sticks were laid on the compass lines over the sample point to form a cross and define the quarters. In each quarter the tree nearest the sample point was selected and the species of the tree, its circumference, and its distance from the sample point were recorded. A tree is defined as one which is more than four inches in diameter at breast height (d.b.h.). The species of the nearest shrub and sapling in each quarter were also recorded. A sapling is a young tree from one inch to four inches d.b.h. A young tree less than one inch d.b.h. is a seedling (Curtis, 1971).

For sampling herbaceous plants, the quadrat method was used (Oosting, 1956). The meter sticks were placed to form a 1 x 1 meter quadrat in the northeast quarter of the sample point. To insure objective sampling the same predetermined position relative to the point was always used. Care was taken to avoid trampling the quadrat area while measuring the trees. In each quadrat the estimated percentage of the quadrat covered by each species was recorded.

In seven of the areas a 2 meter x 2 meter quadrat was placed over the square meter quadrat. Shrubs, saplings, and seedlings over one foot tall present in this larger quadrat were recorded. At each sample point the direction of the slope and the estimated canopy also were noted. Figure 3 shows a sample data sheet.

Plot No. _____ Slope direction _____

Quadrat No. _____ Estim. Canopy _____

Tree Data:

	Species	Distance	Circumference	Nearest Sapling	Nearest Shrub
1.					
2.					
3.					
4.					

1 x 1 Meter Quadrat:

Species	No. Present	% Coverage

2 x 2 Meter Quadrat: (Areas 1 to 7 only)

Species	No. Present

Figure 3. Sample Data Sheet.

Plants that could not be identified in the forest were collected and pressed for later identification. Dr. Max Partch and Sister Remberta Westkemper assisted with the identification of many of the plants. Comparisons were made of many of the specimens with those in the herbarium at St. Cloud State University. Trees and Shrubs of the Upper Midwest by Carl O. Rosendahl, 1955, was used to identify woody species. The Manual of Vascular Plants of Northeastern United States and Adjacent Canada by H. A. Gleason and A. Cronquist, 1963, was used for the final taxonomic designation.

TREATMENT OF DATA

Trees are the dominant plants in a forest community. They influence the light, temperature, moisture conditions, and processes of soil development. The climax, or shade tolerant, trees exert a greater influence than the pioneer trees. When forest stands are arranged along a gradient on the basis of the tree distribution, one would expect to see a similar pattern of distribution in the understory plants (Curtis, 1971).

Three factors were considered when calculating the influence of a tree species on the forest: the size of the trees, the number present, and the uniformity of distribution. Since it is generally believed that there is a strong correlation between basal area and crown cover, basal area provided a measure of the size or dominance of trees. The data on circumference measurements of trees gathered in the forest was changed to basal area which is the cross-section area of the tree trunk measured at 4.5 feet above ground, or at breast height. The exact number of individuals of a species present in a unit area was referred to as the density of that species. The uniformity or regularity with which a species was distributed throughout a stand was its frequency (Cain and Castro, 1959).

Definition of Terms

The following is an explanation of the terms used in the treatment of the data.

Dominance and Relative Dominance - Dominance is the total basal area of one species found in the samples of one area. This number divided by the total basal area of all the species of the area and multiplied by 100 is the relative dominance of that species in percent.

Density and Relative Density - Density indicates the number of individuals of a species per unit area, such as trees per acre. When calculating importance value, density refers to the number of individuals of a species counted in samples taken in one area. This number divided by the total number of individuals of all species and multiplied by 100 is the relative density in percent.

Frequency and Relative Frequency - The frequency value of a species is the number of samples in which that species occurs divided by the total number of samples, multiplied by 100. This frequency value is divided by the sum of the frequency values of all the species and multiplied by 100 to give the relative frequency in percent.

Importance Value - The importance value of a species is the sum of its relative dominance, relative density, and relative frequency. The total importance values of all species in an area or stand is 300. This provides a quantitative method whereby all tree species present are considered in proportion to the influence they exert on a community.

Adaptation Number - The adaptation number (or climax adaptation number) gives an indication of the biological behavior and potentialities of a species (Curtis, 1971). The bur oak (*Quercus macrocarpa*) is considered the most pioneer upland tree species of this area because it is best suited to live in the high light, variable moisture, and immature soil conditions of initial stands. The sugar maple is best equipped to exist in the climax conditions of a terminal forest with low light, medium moisture, and mature soil conditions. Curtis and McIntosh (1951) developed the adaptation number concept while studying the prairie-forest border in Wisconsin. They arranged 95 stands in order of their stage of succession on the basis of their leading tree species, with stands dominated by bur oak on one end of the sequence and sugar maple on the other. The adaptation number rating was accomplished by giving a relative value of one to bur oak, a relative value of ten to sugar maple, and intermediate values to other species according to where they were placed in the sequence from the most pioneer to the most climax stands (Table 2).

Table 2. Adaptation Numbers of Trees in Southern Hardwood Forests (Curtis, 1971).

Species	Adaptation No.
Acer negundo	1.0
Acer rubrum	7.0
Acer saccharum	10.0
Betula papyrifera	5.0
Carpinus caroliniana	8.0
Fraxinus nigra	6.0
Fraxinus pennsylvanica	6.5
Ostrya virginiana	8.5
Populus grandidentata	4.5
Populus tremuloides	1.0
Prunus serotina	3.5
Quercus alba	3.5
Quercus borealis	5.5
Quercus macrocarpa	1.0
Tilia americana	7.5
Ulmus americana	7.5

Adaptation numbers are used to weight the importance value of a species. Low numbers indicate good adaptation to initial stand conditions and high numbers indicate good adaptation to terminal stand conditions.

Weighted Importance Value - The importance value of a species in any one stand multiplied by its adaptation number is the weighted importance value of that species in that stand. It combines an estimate of a plant's behavior with measured plant quantity.

Continuum Index - The continuum index (C.I.) number of a stand is the sum of the weighted importance values of all the tree species in that stand. Possible index numbers range from 300 for a stand of all bur oak to 3000 for a stand composed entirely of sugar maple. Stands of mixed species have intermediate continuum index values indicating the successional stages of the stands between the most pioneer (C.I. = 300) to the most climax (C.I. = 3000). Stands are then arranged on a continuum gradient using these index values as the abscissa. Each tree species in a stand contributes to the index number of that stand in proportion to its actual importance value in that stand and its potentialities for adapting to climax conditions as shown by its adaptation number. Therefore the continuum index is a means of using all the tree species in a stand to express the position of the stand on a gradient. A summary of the tree data used in determining the continuum index of each study plot is given in Appendix II.

Presence - The percent of plots in which a species is found is termed its presence.

Species Density - The average number of species in all plots is called species density. Those plants listed only to genus designation are treated as one species.

Prevalent Species - When the total list of species found in the forest are arranged in decreasing order of their presence percentages, the prevalent species are the topmost species counted off to a number equal to the species density of the forest. The prevalent species are the most widely distributed species in the forest.

Index of Homogeneity - Homogeneity refers to the regularity of species distribution in a community. The index of homogeneity is expressed as a ratio of the sum of the presence of the prevalent species to the total sum of presence of all species in the community. If the forest were perfectly homogeneous the index of homogeneity would be 100%.

Frequency x Presence Index - The measure of the commonness of a species in all the study plots is shown on a frequency x presence index. The species are ranked according to the product of their presence and their average frequency. A plant found in all the quadrats of all the plots would have a frequency x presence (f x p) value of 10000. A rare plant would have a f x p value near zero.

RESULTS

Continuum Index Values

In this study of the upland areas of St. John's Forest the continuum index numbers of the twelve study plots ranged from 1470 to 2274. The average continuum index value of all the plots was 1956. Three plots had considerably lower continuum index numbers than the average value. Plot 3, the area that had been cut fifty years ago, had the lowest continuum index number, 1470. Even so, these stands are not the pioneer oak woods so typical of much of Stearns County. Table 3 lists the continuum index values of the plots. Figures 4 and 5 show the positions of the plots on the continuum index gradient.

Table 3. Continuum Index Values of Plots.

Continuum Index Number	Plot Number	Continuum Index Number	Plot Number
1470	3	2037	1
1703	4	2093	7
1710	9	2098	6
1922	12	2103	5
1944	10	2145	2
1971	8	2274	11

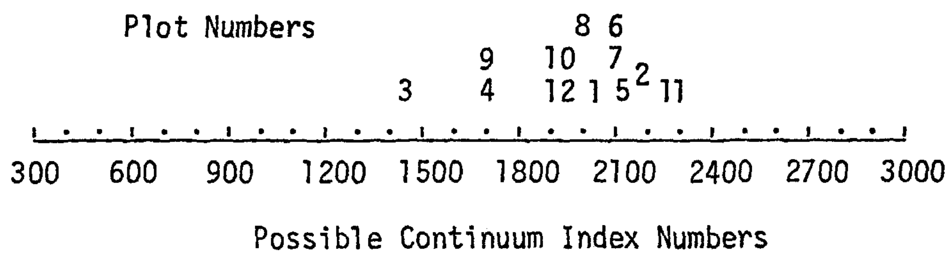

Figure 4. Distribution of Plots on Continuum Index Gradient.

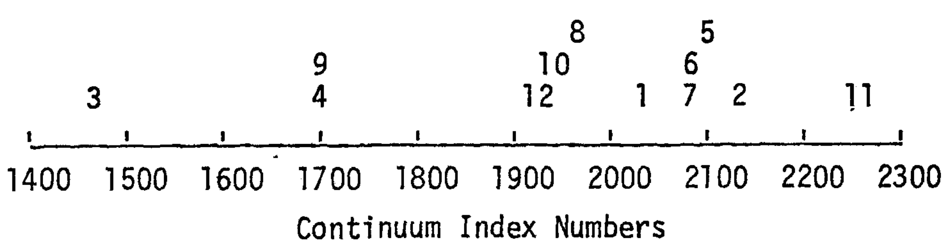

Figure 5. Enlargement of Portion of Continuum Index Gradient.

Tree Data

Seventeen species of trees were present in the twelve plots. Of these, seven species were present in all the plots. They were red oak, white oak, bur oak, sugar maple, red maple (*Acer rubrum*), ironwood (*Ostrya virginiana*), and American elm. Only two species achieved highest importance values (Table 4). Red oak was highest in the eight plots with the lowest continuum index numbers. Sugar maple had the highest importance value in the four plots with the highest continuum index numbers. Five species were second highest in importance value: red oak, sugar maple, and red maple were second highest in three plots each; basswood in two plots, and trembling aspen in one plot. However, according to weighted importance value which gives consideration to the potentialities of the species, the trees ranked somewhat differently. Table 4 shows that in weighted importance value sugar maple and red oak each ranked highest in six plots. This change in rank occurred because of the difference in the adaptation numbers used in calculating the weighted importance value. Sugar maple has a high adaptation number of 10 while red oak's adaptation number is 5.5. The second highest ratings differed only slightly between importance value and weighted importance value.

Table 20 in Appendix I gives the importance values (I.V.) of the trees in all plots. The two species having the highest average importance values, red oak and sugar maple, had importance values that were relative to the position of the plots on the continuum index gradient as shown in Figure 6. Red oak had a high I.V. in plots low on the C.I. gradient, higher I.V.'s in the middle plots, and declined in I.V. in the plots of the top C.I. range. Sugar maple had lower importance values in the plots lower on the C.I. gradient and reached its highest I.V. in plots highest on the C.I. These patterns illustrate the abilities of the two species to survive in a forest as it matures. Red oak, although the most shade tolerant of the oaks, is less shade tolerant than sugar maple and is less able to reproduce as the forest gets older and approaches a climax condition. Sugar maple, very shade tolerant, becomes one of the dominant trees in a climax forest.

Table 4. Comparison of Placement of Trees in Importance Value and Weighted Importance Value.

Species	Number of Plots in Which Species Ranked Highest in Importance Value	Number of Plots in Which Species Ranked Highest in Weighted Importance Value
Red oak	8	6
Sugar maple	4	6
	Number of Plots in Which Species Ranked Second Highest in I.V.	Number of Plots in Which Species Ranked Second Highest in Weighted I.V.
Red oak	3	3
Sugar maple	3	4
Red maple	3	3
Basswood	2	1
Trembling aspen	1	0
Ironwood	0	1

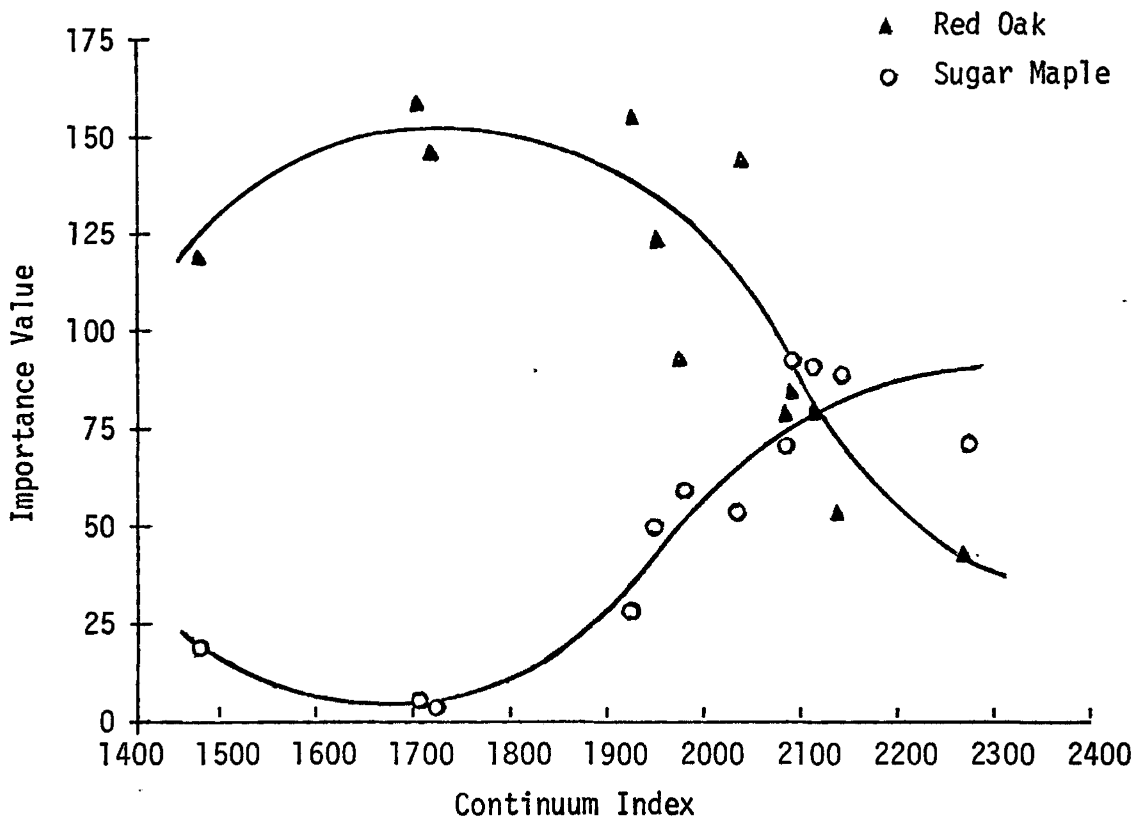

Figure 6. Relationship of Importance Values of Sugar Maple and Red Oak to Continuum Index.

Data on the importance value, basal area, frequency, and density of all the tree species in all the plots are given in Appendix I, Tables 20, 21, 22, and 23. Table 5 gives a summary of the average values for these data. The species are listed from their highest to lowest average importance values. When listed in that order, average frequency and average density follow a similar pattern of high to low values. Average basal areas, however, do not show the same pattern of rank. For instance, the relatively large basal areas of basswood (106.4 sq. in.) and white oak (108.4 sq. in.) rank below three species with smaller basal areas. Ironwood, with the small basal area of

19.5 sq. in. is found in fourth place. Ironwood is a small understory tree common in the forest. Basswood and white oak are not as abundant, but when present are often large trees.

Table 5. Summary of Data on Importance Value, Basal Area, Frequency, and Density of Trees in All Plots.

Species	Aver. I.V.	Aver. Freq.	Aver. Den.	Aver. B.A.
Quercus borealis	106.7	65.6	50.6	148.0
Acer saccharum	54.3	45.8	32.8	73.8
Acer rubrum	34.1	35.4	20.2	60.4
Ostrya virginiana	19.5	24.0	13.6	19.5
Tilia americana	15.4	15.8	7.3	106.4
Quercus alba	15.1	14.6	7.0	108.4
Ulmus americana	14.9	15.0	7.3	87.7
Betula papyrifera	9.3	10.0	4.8	72.4
Quercus macrocarpa	8.1	8.8	4.3	63.8
Populus grandidentata	8.1	7.1	4.2	67.0
Populus tremuloides	6.8	4.8	3.4	80.7
Fraxinus pennsylvanica	5.0	5.0	2.5	77.6
Fraxinus nigra	1.0	1.3	0.6	31.6
Prunus serotina	0.9	1.3	0.5	29.7
Acer negundo	0.5	0.8	0.3	16.5
Carpinus caroliniana	0.1	0.2	0.1	16.7
Amelanchier spp.	0.1	0.2	0.1	17.9

Tree and Sapling Frequency

To discover what changes are taking place in the forest, a comparison was made of the average frequencies of trees to the average frequencies of saplings. See Table 6. Not all saplings survive to become trees. How many saplings of a species must be present to maintain the frequency of the tree would be difficult to ascertain, but large differences between tree and sapling frequencies certainly indicate a change in populations. Four species, sugar maple, ironwood, Juneberry (*Amelanchier*), and blue beech (*Carpinus*), had higher average sapling frequencies than average tree frequencies. All other species had average sapling frequencies lower than average tree frequencies. All oak species had much lower sapling frequencies.

Table 6. Comparison of Average Tree Frequency and Average Sapling Frequency. * indicates sapling frequency higher than tree frequency.

Species	Average Tree Frequency	Average Sapling Frequency
Quercus borealis	65.6%	1.3%
Acer saccharum	45.8	62.5*
Acer rubrum	35.4	13.3
Ostrya virginiana	24.0	78.1*
Tilia americana	15.8	7.5
Ulmus americana	15.0	9.6
Quercus alba	14.6	0.0
Betula papyrifera	10.0	0.4
Quercus macrocarpa	8.8	1.7
Populus grandidentata	7.1	0.0
Fraxinus pennsylvanica	5.0	2.7
Populus tremuloides	4.8	0.2
Fraxinus nigra	1.3	0.4
Prunus serotina	1.3	0.0
Acer negundo	0.8	0.2
Carpinus caroliniana	0.2	1.5*
Amelanchier spp.	0.2	5.6*

Tree Dominance and Understory Distribution

Because trees are considered the dominant members of the forest community and therefore strongly influence the environment of the understory plants, an attempt was made to discover a correlation between tree dominance as represented by continuum index values and the understory distribution. Table 26 in Appendix I gives the frequencies of species found in the quadrat samples. Some plants were identified only as to genus rather than species because of some taxonomic difficulty. The species that reached their highest frequencies in the plot with the lowest C.I. value were listed first; the species that reached their highest frequencies in the plot with the second lowest C.I. value were listed next, etc.

In Plot 3, which had the lowest C.I. value, *Geranium maculatum* and *Zanthoxylum americanum* had much higher frequencies than in the other plots. In Plots 4 and 9, which also were in the lower C.I. range, *Viola* spp., *Cornus alternifolia, Aster macrophyllus, Amphicarpa bracteata,* and *Circaea quadrisulcata* showed definitely higher frequencies. In the middle range of the continuum index, red oak, American elm, red maple, and ironwood seedlings were highest. In the high C.I. range, ash and sugar maple seedlings, *Anemone quinquefolia, Osmorhiza Claytoni, Carex* spp., *Uvularia grandiflora,* and *Arisaema triphyllum* were highest.

Some species were not present in all plots. For most such species this seemed to be based on chance introduction, disturbance of the area in the past, the presence of ponds providing an area with more moisture, or some reason other than the area's position on a continuum index gradient. There were a few exceptions. The distributions of *Rosa*, *Populus*, and *Dirca* follow the pattern of the C.I. gradient. *Rosa* was not found in the three plots of highest C.I. values. It is commonly found on prairies and the edges of forests and usually not in mature forests. *Populus tremuloides* and *P. grandidentata*, pioneer trees, were not found in the two highest C.I. plots. *Dirca palustris*, found most commonly in mature forests, was not present in the five plots of lowest C.I. values.

In the quadrat studies, *Carex* spp. had the highest average frequency, 51.2%. (This high frequency may be because the members of the *Carex* genus were not identified to species.) Sugar maple was a close second with an average frequency of 48.9%. Sugar maple also had the highest frequency in any one plot with a frequency of 87.5% in Plot 2.

Five shrub genera and one species of woody vine were present in all plots (Appendix I, Table 25). Three of these had rather high average frequencies: *Prunus* spp. (54.0%), *Amelanchier* spp. (28.8%), and *Ribes cynosbati* (47.1%). Three species present in all plots with lower average frequency were *Viburnum Rafinesquianum* (9.2%), *Parthenocissus* sp. (12.5%), and *Rubus* sp. (7.7%). *Prunus* and *Amelanchier* had higher frequencies in the middle C.I. range. *Ribes* and *Rubus* were rather evenly distributed, but reached their highest frequencies in the upper C.I. range. *Parthenocissus* and *Viburnum* frequencies followed no special pattern.

Zanthoxylum americanum was present in all but one plot and reached its highest frequency in Plot 3 (lowest C.I. value). *Cornus* *alternifolia* was present in all but two plots and reached its highest frequency in Plot 4 which also was in the low C.I. range. *Hamamelis virginiana* was found only in Plot 7 but only in a limited area. *Ilex* sp. was found near the small ponds scattered through some areas of the forest.

Homogeneity

In determining the homogeneity of the forest the species density (average number of species in all plots) was calculated to be 65.7. The number of species in each plot ranged from 60 to 71 species as shown in Table 7.

Table 7. Number of Species Found in Each Plot.

Plot No. and C.I. No.	No. of Species	Plot No. and C.I. No.	No. of Species
3 - 1470	70	1 - 2037	65
4 - 1703	70	7 - 2093	65
9 - 1710	69	6 - 2098	64
12 - 1922	64	5 - 2103	71
10 - 1944	65	2 - 2145	62
8 - 1971	63	11 - 2274	60

When all the species of the forest were ranked in decreasing order of their presence values, the top 66 (species density) were the prevalent species. Table 8 lists the prevalent species with their presence values, their average frequency, their frequency times presence (f x p) index, and their community of modality (type of community in which species reaches its maximum presence).

Table 8. Prevalent Species in St. John's Forest. Community of Modality is the native community in which species achieved maximum presence as listed by Curtis, 1971.

Species	Presence	Frequency	f x p index	Community of Modality
Carex spp.	100%	51.2%	5120	
Acer saccharum	100	48.9	4890	SM
Acer rubrum	100	32.9	3290	NWM
Ostrya virginiana	100	30.8	3080	SM
Osmorhiza Claytoni	100	28.7	2870	SDM
Viola spp.	100	22.3	2230	
Circaea quadrisulcata	100	22.1	2210	SDM
Aster macrophyllus	100	19.0	1900	BF
Oryzopsis asperifolia	100	18.7	1870	BF
Quercus borealis	100	18.7	1870	SDM
Amphicarpa bracteata	100	17.7	1770	SDM
Prunus spp.	100	17.1	1710	SD
Aralia nudicaulis	100	14.2	1420	NDM
Solidago flexicaulis	100	11.7	1170	SM
Galium triflorum	100	11.5	1150	BF
Uvularia grandiflora	100	10.4	1040	SDM
Polygonatum pubescens	100	10.0	1000	NM
Ulmus americana	100	7.9	790	SWM
Ribes cynosbati	100	7.7	770	SDM
Smilacina racemosa	100	7.7	770	SD
Fraxinus pennsylvanica	100	7.3	730	SWM
Asplenium sp.	100	6.2	620	
Parthenocissus sp.	100	5.8	580	SD
Phryma Leptostachya	100	5.8	580	SDM
Rubus spp.	100	3.5	350	SDM
Amelanchier spp.	100	3.5	350	
Viburnum Rafinesquianum	100	1.0	100	SDM
Quercus macrocarpa	100	0.4	40	OO
Quercus alba	100	0.2	20	SD
Geranium maculatum	92	11.5	1058	SDM
Uvularia sessilifolia	92	11.2	1030	NDM
Tilia americana	92	6.7	616	SM
Zanthoxylum americanum	92	5.4	497	SDM
Desmodium nudicaulis	92	4.6	423	SDM
Cornus alternifolia	92	3.5	322	SDM
Betula papyrifera	92	3.3	304	NDM
Anemone quinquefolia	83	8.7	722	NDM
Pyrola spp.	83	4.0	332	
Caulophyllum thalictroides	83	1.7	141	SM
Botrychium virginianum	83	1.5	124	SDM
Vitis aestivalis	83	0.6	50	SDM
Maianthemum canadense	75	4.0	300	BF

Table 8. Continued.

Species	Presence	Frequency	f x p index	Community of Modality
Populus grandidentata	75	1.9	142	ND
Oryzopsis racemosa	75	1.3	97	SDM
Aquilegia canadensis	75	0.8	60	CG
Brachyelytrum erectum	75	0.4	30	SDM
Milium effusum	67	2.7	181	NM
Sanicula gregaria	67	2.5	167	SDM
Geum canadense	67	2.1	141	SDM
Populus tremuloides	67	2.1	141	SDM
Symphoricarpus sp.	67	1.9	127	
Rhus radicans	67	1.0	67	SW
Smilax herbacea	67	1.0	67	SD
Cryptotaenia canadensis	67	1.0	67	SDM
Actaea rubra	67	0.2	13	BF
Trillium cernuum	58	1.5	87	BF
Smilacina stellata	58	1.5	87	SD
Goodyera pubescens	58	0.2	12	SDM
Hepatica americana	50	7.3	365	BF
Trientalis borealis	50	1.9	95	BF
Cornus racemosa	50	1.5	75	SD
Aster shortii	50	1.0	50	SDM
Fragaria virginiana	50	0.8	40	
Carpinus caroliniana	50	0.2	10	BF
Dirca palustris	42	2.3	97	NM
Laportea canadensis	42	2.1	88	SW

Key to Communities of Modality:

BF	Boreal Forest
CG	Cedar Glade
ND	Northern Dry Forest
NDM	Northern Dry-Mesic Forest
NM	Northern Mesic Forest
NWM	Northern Wet-Mesic Forest
OO	Oak Opening
SD	Southern Dry Forest
SDM	Southern Dry-Mesic Forest
SM	Southern Mesic Forest
SWM	Southern Wet-Mesic Forest
SW	Southern Wet Forest

The index of homogeneity for St. John's forest was 83.7%. The formula used for this calculation was:

$$\frac{\text{Sum of presence of prevalent species}}{\text{Sum of presence of all species}} \times 100 = \text{Index of Homogeneity (\%)}$$

$$\frac{5495}{6563} \times 100 = 83.73\%$$

Using the f x p index as a measure of the commonness of a species, the genus *Carex* ranked highest with a f x p index of 5120. Sugar maple was the most common species with a f x p index of 4890. Other common species were red maple, ironwood, and *Osmorhiza Claytoni*. Only 19 of the total 127 species (15%) had f x p values over 1000. Twenty-eight species (22%) had values over 500. Twenty species ranked near zero. A few of the rare species were *Acer negundo*, *Orchis spectabilis*, *Habenaria* sp., and *Oxalis* sp.

All species (not including those listed only to genera) with a f x p index over 500 had a community of modality as follows: SDM:8, SM:4, SD:3, SWM:2, NDM:3, NM:1, BF:3.

Comparison of Cutover Area with Other Plots

Plot 3, the area of second-growth forest, presented a special problem. Because many of the trees had multiple trunks, the appearance of this area was one of clusters of trees rather than the single trunks common in most of the forest. The problem was how to show this difference. Using the point-quarter method of measuring the trees did not give data to indicate these multiple trunks and therefore did not give a true picture of this area. When only one trunk of a tree with several trunks was measured in each quarter, the results were the same as in a forest of single trees in the same positions.

In an attempt to show this difference, the circumference of the trunk closest to the sample point was recorded first, and then the circumferences of all the trunks of the clone were recorded. A comparison was then made of the importance values of the trees with dominance based on the nearest trunk only and then with dominance based on the total basal area of all the trunks. This entailed a good deal of work in Plot 3 but little extra work in the other plots.

Table 9 shows a comparison of continuum index values obtained with dominance determined by the two different methods. The only noteworthy difference occurred in Plot 3. There the continuum index values, determined by the two different methods, differed by +36.8. In the other plots the differences ranged from -6.4 to +6.1.

Table 10 compares the importance values and weighted importance values of the major trees in plot 3 as determined by the two methods. Red oak showed an increase of 16.8 in importance value and an increase of 92.0 in weighted importance value when dominance was based on the total basal area of all trunks in a clone. The sprouting ability of red oak made this species show the greatest difference between the two sampling methods (Curtis, 1971). The slight increase in sugar maple is probably not statistically significant. The two aspen species (*Populus*) had lower importance values in the second sampling method only because their importance was less relative to the more important red oak.

(Data in other sections of this paper use only measurement of one trunk nearest the sample point.)

Table 9. Comparison of Continuum Index Values Using Dominance Determined by Two Methods.

Plot	Continuum Index Values: Dominance based on basal area of nearest trunk in the clone	Continuum Index Values: Dominance based on total basal area of all trunks in clone	Difference
3	1469.6	1505.4	+36.8
4	1703.4	1704.1	+ 0.7
9	1709.9	1713.2	+ 3.3
12	1922.4	1923.2	+ 0.8
10	1943.5	1943.2	- 0.3
8	1970.8	1971.4	+ 0.6
1	2036.9	2041.9	+ 5.0
7	2092.8	2092.1	- 0.7
6	2098.3	2091.9	- 6.4
5	2103.3	2109.4	+ 6.1
2	2145.1	2145.8	+ 0.7
11	2274.0	2273.6	- 0.4

Table 10. Comparison of Importance Values and Weighted Importance Values of the Major Trees in Plot 3 Using Dominance Determined by Two Methods.

Species	Importance Value: Dominance based on basal area of nearest trunk in the clone	Importance Value: Dominance based on total basal area of all trunks in clone	Difference
Quercus borealis	120.5	137.3	+16.8
Populus tremuloides	42.0	34.4	- 7.6
Populus grandidentata	37.5	32.5	- 5.0
Acer saccharum	18.7	19.0	+ 0.3

Species	Weighted Importance Value: Dominance based on basal area of nearest trunk in the clone	Weighted Importance Value: Dominance based on total basal area of all trunks in clone	Difference
Quercus borealis	662.9	754.9	+92.0
Populus tremuloides	42.0	34.4	- 7.6
Populus grandidentata	168.5	146.4	-22.1
Acer saccharum	186.6	190.0	+ 3.4

The unusual appearance of Plot 3 can also be shown by a comparison of the density of the trees to the density of trunks. The number of trees per acre were calculated by the formula:

$$\text{Density (trees per acre)} = \frac{\text{43560 square feet per acre}}{d^2}$$

d = average distance of trees to sample points (Curtis and Cottam, 1962).

This density multiplied by the average number of trunks per tree gives the trunk density and an indication of the comparative appearance of the various plots.

Table 11 shows Plot 3 had 281.9 trees per acre. But since there were 1.77 trunks per tree, the trunk density was 499 per acre. In all other plots the trunk density was not much greater than tree density because the number of trunks per tree was much less, ranging from 1.03 to 1.16. Plot 3 had 281.9 trees per acre as compared to an average of 223.8 trees per acre in all other plots. Its trunk density of 499 per acre compared to an average of 245.6 for all other plots. Figure 7 gives a visual comparison of tree density and trunk density showing the significant difference in the trunk density and tree density in Plot 3 and how these densities compare to those in the other plots.

A comparison also was made of the size of the trees in Plot 3 to the size of the trees in the other plots. Table 12 lists the average basal area of the trunk nearest the sample point, the average total basal area of all the trunks on multiple trees, and the average basal area of single tree trunks in all other plots. Even using the sum of all trunks in Plot 3, none, except *Prunus serotina*, showed a greater average basal area than the average basal area in all other plots. The trunks in the clones of Plot 3 were much smaller than the average in the other plots. The average basal area of all trunks in Plot 3 was 46.0 sq. in. or a diameter of 7.7 in. The average basal area of all trees, excluding Plot 3, was 98.4 sq. in. or a diameter of 11.3 in. So, while Plot 3 had about twice the number of trunks per acre as the other plots, the trunks were much smaller.

Table 11. Tree Density Compared to Trunk Density.

Plot No. and C.I. No.	Tree Density	Average Number Trunks/Tree	Trunk Density
3 - 1470	281.9	1.77	499.0
4 - 1703	228.7	1.06	242.4
9 - 1710	227.7	1.11	252.7
12 - 1922	225.4	1.08	243.4
10 - 1944	227.8	1.04	236.9
8 - 1971	235.8	1.11	261.7
1 - 2037	225.8	1.11	250.6
7 - 2093	267.6	1.06	283.7
6 - 2098	241.9	1.21	292.7
5 - 2103	246.9	1.09	269.1
2 - 2145	149.6	1.03	154.1
11 - 2274	184.6	1.16	214.1
Average of all plots	228.7	1.16	266.7
Average of all plots excluding No. 3	223.8	1.10	245.6

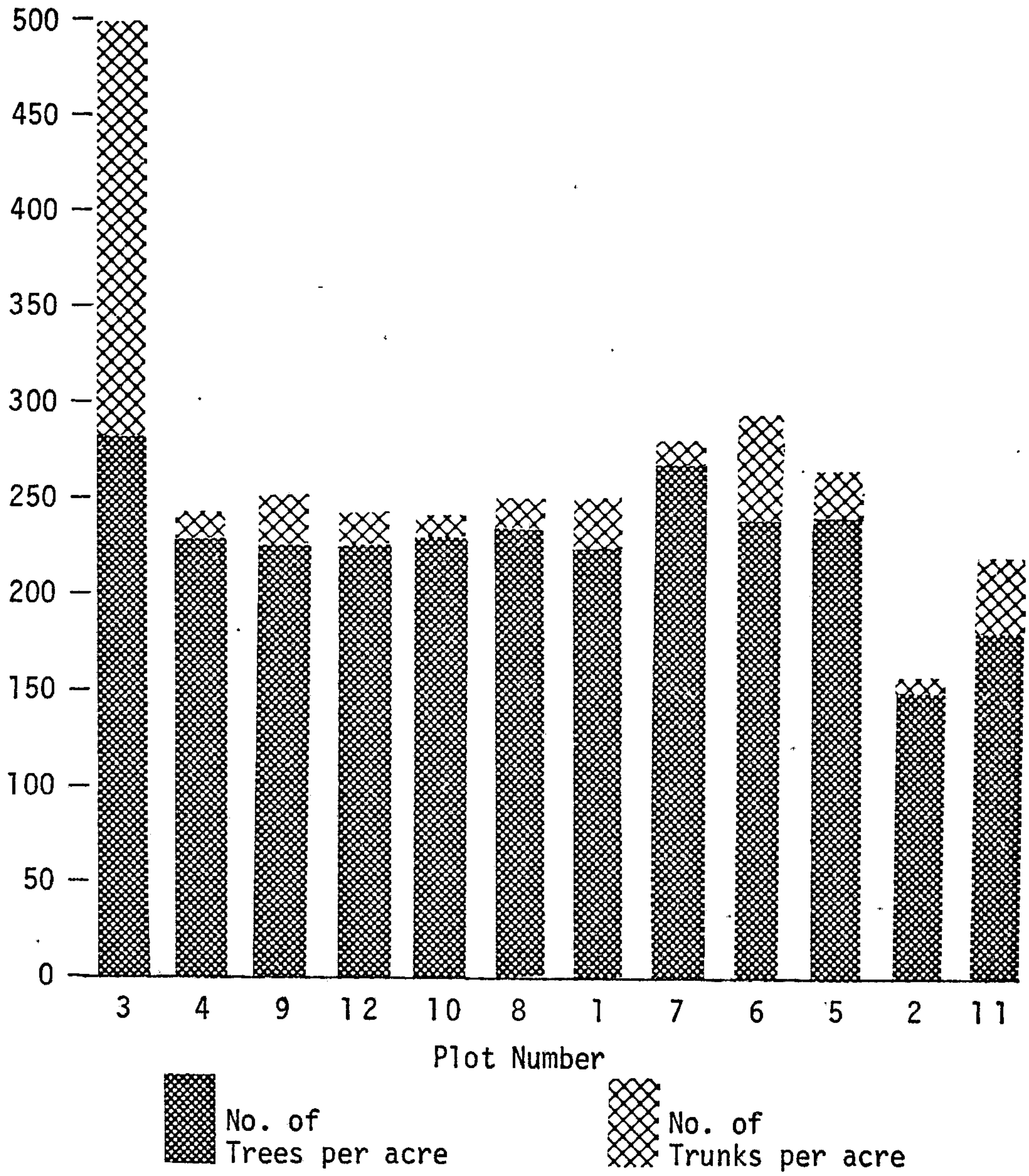

Figure 7. Comparison of Tree Density to Trunk Density.

Table 12. Comparison of Basal Areas in Plot 3 with All Other Plots. * indicates the only basal area to exceed the average basal area in all other plots.

Species	Plot 3				Average B.A. in all other plots (sq. in.)
	Aver. B.A. of trunk nearest sample point (sq. in.)	Average B.A. using sum of all trunks on multiple trees (sq. in.)	Percent increase	Average B.A. of all trunks (sq. in.)	
Quercus borealis	56.7	138.5	144	53.5	158.0
Acer saccharum	22.1	44.3	100	29.5	75.5
Prunus serotina	23.0	43.4*	89	21.7	31.0
Quercus macrocarpa	26.1	44.2	69	28.6	73.9
Quercus alba	28.2	47.1	67	27.5	115.6
Acer rubrum	20.2	29.3	45	21.0	62.6
Betula papyrifera	46.4	61.5	33	36.9	73.8
Ostrya virginiana	15.1	17.2	14	14.7	19.7
Populus grandident.	43.6	47.2	8	44.9	82.6
Populus tremuloides	52.7	52.7	0	52.8	116.3
Ulmus americana	69.7	69.7	0	69.7	88.6
Fraxinus pennsylvan.	61.9	61.9	0	61.9	78.7
Tilia americana	0	0	0	0	106.4
Average of all trees	44.7			46.0	98.4

The frequencies of several species of both trees and understory plants were considerably different in Plot 3. For instance, no basswood trees, saplings or seedlings were present in any of the samples taken in that plot. *Luzula*, *Rosa*, *Geranium*, *Parthenocissus*, and *Zanthoxylum* had their highest frequencies in Plot 3. Table 13 lists species showing notable differences in frequency in Plot 3 as compared to the other plots.

Table 13. Frequencies in Which Certain Species Occur in Plot 3 Compared With Their Frequencies in All Other Plots.

	Frequency in Plot 3	Average frequency in all plots Excluding Plot 3
Species showing much higher frequencies in Plot 3		
Quercus macro. - trees	17.5%	7.9%
- saplings	17.5	0.2
Populus trem. - trees	25.0	3.0
Populus grand. - trees	30.0	5.0
Acer rubrum - saplings	25.0	12.3
Fraxinus penn. - saplings	10.0	2.1
Agrimonia sp.	5.0	0
Geranium maculatum	35.0	9.3
Luzula acuminata	2.5	0
Parthenocissus sp.	17.5	4.8
Rosa sp.	2.5	0
Zanthoxylum americanum	25.0	3.6
Species showing much lower frequencies in Plot 3		
Tilia amer. - trees	0	17.5
- saplings	0	8.2
Acer sacc. - trees	17.5	48.4
- seedlings	5.0	53.0
Acer rubrum - trees	20.0	36.8
Amelanchier spp. - shrubs	10.0	30.5
Aralia nudicaulis	2.5	15.2
Galium triflorum	5.0	12.0

Comparison of North and South Slopes

Much of St. John's forested terrain is very hilly. In one area slopes have been cleared for down-hill skiing. In some areas the gradient was so steep that equipment used while gathering data for this study did occasionally roll downhill. The question arose whether vegetation on the southern slopes would differ from that on the northern slopes. Early in the spring before leaves are on the trees, southern and southwestern slopes would surely be warmer than their opposite slopes. That was evident from snow melting first on southern slopes.

In seven of the study plots, the direction of slope and approximate location of the sample point on the slope were recorded. After compilation of the data, thirty-four points were found to be located on southern and southwestern slopes and thirty-three points on northern and northeastern slopes. The samples were too few to support definite conclusions, but some interesting trends were apparent. Tables 14, 15, 16, and 17 compare the frequencies of trees, saplings, shrubs, and herbaceous plants on north and south slopes. In each table the species are arranged from those that have highest frequencies on southern slopes to those with highest frequencies on northern slopes.

No bur oak or black cherry trees were found on northern slopes. See Table 14. Birch trees were found three times more often on northern slopes than on southern slopes. Red oak, red maple, basswood, trembling aspen, and green ash were present more frequently on northern slopes. Ironwood, large-toothed aspen and American elm had higher frequencies on southern slopes.

Table 14. Comparison of Frequencies of Trees on North and South Slopes. Average Frequency was calculated from all sample points in the seven plots in which slope direction was recorded.

Species	Frequency on South and S.W. Slopes	Frequency on North and N.E. Slopes	Average Frequency
Higher frequencies on south slopes			
Ostrya virginiana	35.3%	24.2%	26.4%
Quercus macrocarpa	23.5	0	10.0
Populus grandidentata	11.8	6.1	5.0
Ulmus americana	8.8	3.0	14.3
Prunus serotina	5.9	0	1.8
Quercus alba	5.9	3.0	12.5
Higher frequencies on north slopes			
Fraxinus pennsylvanica	0	6.1	6.1
Populus tremuloides	5.9	9.1	3.9
Tilia americana	11.8	15.2	11.4
Betula papyrifera	5.9	18.2	12.5
Acer rubrum	23.5	30.3	37.5
Acer saccharum	44.1	48.5	46.1
Quercus borealis	64.7	84.8	62.9

Table 15. Comparison of Frequencies of Saplings on North and South Slopes. Average frequency was calculated from all sample points in the seven plots in which slope direction was recorded.

Species	Frequency on South and S.W. Slopes	Frequency on North and N.E. Slopes	Average Frequency
Higher frequencies on south slopes			
Ostrya virginiana	100.0%	68.7%	79.6%
Ulmus americana	14.7	0	9.6
Higher frequencies on north slopes			
Prunus spp.	0	3.1	0.4
Tilia americana	8.8	9.4	6.8
Amelanchier spp.	2.9	15.6	7.5
Acer rubrum	0	15.6	12.1
Acer saccharum	47.1	71.9	57.1

Table 16. Comparison of Frequencies of Shrubs and Vines on North and South Slopes. Average frequency was calculated from all sample points in the seven plots in which slope direction was recorded.

Species	Frequency on South and S.W. Slopes	Frequency on North and N.E. Slopes	Average Frequency
Higher frequencies on south slopes			
Amelanchier spp.	41.2%	36.4%	30.0%
Cornus alternifolia	32.4	24.2	21.8
Dirca palustris	32.4	27.3	19.3
Zanthoxylum	23.5	9.1	13.6
Parthenocissus	8.8	6.1	9.6
Cornus racemosa	5.9	0	2.9
Juniperus communis	2.9	0	0.4
Higher frequencies on north slopes			
Celastrus scandens	0	3.0	0.4
Rubus spp.	0	3.0	6.4
Rhus radicans	2.9	3.0	2.1
Viburnum Rafines.	14.7	24.2	10.7
Ribes cynosbati	35.3	57.6	50.0
Prunus spp.	52.9	60.6	50.7

Table 17. Comparison of Frequencies of Herbaceous Plants on North and South Slopes.

Species	South and S.W. Slopes	North and N.E. Slopes
Higher freq. on south slopes		
Sedges	52.9%	43.3%
Grasses	32.4	13.3
Circaea quadrisulcata	29.4	13.3
Amphicarpa bracteata	23.5	10.0
Solidago flexicaulis	20.6	10.0
Smilacina racemosa	17.6	13.3
Galium triflorum	14.7	3.3
Maianthemum canadense	11.8	3.3
Uvularia grandiflora	11.8	10.0
Geranium maculatum	11.6	6.6
Sanicula gregaria	8.8	0.0
Polygonatum pubescens	8.8	6.6
Caulophyllum thalictroides	5.9	0.0
Phryma leptostachya	5.9	3.3
Aquilegia canadensis	2.9	0.0
Desmodium nudiflorum	2.9	0.0
Fragaria virginiana	2.9	0.0
Laportea canadensis	2.9	0.0
Ranunculus abortivus	2.9	0.0
Smilax herbacea	2.9	0.0
Higher freq. on north slopes		
Thalictrum dioicum	2.9	3.3
Arisaema triphyllum	0.0	3.3
Goodyera pubescens	0.0	3.3
Monotropa uniflora	0.0	3.3
Trientalis borealis	0.0	3.3
Pyrola spp.	0.0	10.0
Aster macrophyllus	11.8	13.3
Hepatica americana	5.9	13.3
Ferns	5.9	13.3
Anemone quinquefolia	14.7	20.0
Uvularia sessilifolia	14.7	20.0
Aralia nudicaulis	17.6	26.6
Osmorhiza Claytoni	14.7	26.6
Viola spp.	17.6	30.0

Table 15 shows that the frequencies of saplings followed similar patterns but with more pronounced differences. *Prunus* spp. were an exception; *Prunus* saplings were found on north slopes where no trees were found. Fewer species of saplings than trees were present; no saplings of the more pioneer trees were present on either the north or south slopes. *Amelanchier* saplings, which rarely reach tree size, were more frequent on north slopes than south slopes.

Of the shrubs in Table 16, *Cornus alternifolia* and *Zanthoxylum americanum* had much greater frequencies on southern slopes; *Ribes Cynosbati*, and *Viburnum Rafinesquianum* on northern slopes. No *Cornus racemosa* or *Juniperus communis* were found on northern slopes. No *Celastrus scandens* or *Rubus* spp. were found on southern slopes.

Herbaceous plants (Table 17) growing with definitely greater frequencies on southern slopes were *Amphicarpa bracteata, Circaea quadrisulcata, Galium triflorum, Geranium maculatum, Maianthemum canadense*, *Solidago flexicaulis*, and the grasses. Those growing with definitely greater frequencies on northern slopes were *Anemone quinquefolia, Aralia nudicaulis, Hepatica americana, Osmorhiza Claytoni, Pyrola* spp., *Uvularia sessilifolia*, *Viola* spp., and the ferns.

When considering modality of species, south slopes had a major grouping of eight species modal in southern dry-mesic forests (Table 18). The north slope species were about one third each modal in southern dry-mesic forests, northern dry-mesic forests and boreal forests. There was a noticable lack of herbaceous species characteristic of wet or wet-mesic forests on either the north or south slopes.

Table 18. Number of Modal Species Having Highest Frequency on North or South Slopes.

Type of Community in Which Species is Modal	No. of Modal Species Having Highest Freq. on South Slopes	No. of Modal Species Having Highest Freq. on North Slopes
Southern Dry Forest	2	0
Southern Dry Mesic Forest	8	4
Southern Mesic Forest	2	0
Southern Wet Mesic Forest	0	0
Southern Wet Forest	1	0
Northern Dry Forest	1	0
Northern Dry Mesic Forest	0	4
Northern Mesic Forest	1	0
Northern Wet Mesic Forest	0	0
Northern Wet Forest	0	0
Boreal Forest	2	3
Cedar Glade	1	0

DISCUSSION

All of the areas studied in St. John's forest fit the southern dry-mesic type of forest described by Curtis (1971) as having a Continuum Index value of from 1300 to 2300. Within that range, the forest was not uniform and showed some interesting variations.

Plots with Lowest Continuum Index Values

The plots with the lowest index numbers (Plots 3, 4, and 9) are in the south and southeastern part of the forest. See Figure 2. Several reasons why these south and southeastern areas had lower index values could be 1) a natural stage of succession of a comparatively younger section of the forest, 2) past history of ground fires, and 3) little selective cutting. Bur oak reached its highest importance values in these areas. This species is very intolerant of shade and will not reproduce in a closed forest. These areas must have at one time been open enough for bur oak to germinate and reach maturity. Leatherwood was not found in these plots. It is usually found only in old growth stands (Stearns, 1951).

In these three plots sugar maple had its lowest frequency. In Plots 4 and 9 sugar maple had its lowest importance value and in Plots 3 and 9 it had its lowest average basal area (Appendix I, Tables 20, 21, and 22). Since sugar maple is perhaps the most sensitive to fire of any trees in this area, these low values could indicate ground fires at some time in the forest history. Fires in forests generally act as retrogressive agents returning succession to earlier conditions (Kozlowski and Ahlgren, 1974). Plots 3 and 4 are somewhat less protected from fire by water areas than are some of the other plots. It was interesting to observe while revisiting Plot 4 in the spring of 1975 that a ground fire had destroyed the leaf litter in a large area since the previous fall.

These areas are also most remote from the University and least accessible for selective cutting of trees for lumber and fuel. Plots 4 and 9 have very few stumps. Plot 3 had no recent cutting but was, as stated, cut over in 1926. Since they had not been selectively cut, red oak had high importance values in these plots.

Plots with Highest Continuum Index Values

Plot 11, which had the highest continuum index number, is in the southwest corner of the forest, west of Lake Sagatagan. The other plots of high index values (Plots 2, 5, 6, and 7) lie in the central part of the forest. Plots 5, 6, and 7 are in Section 6, and Plot 2 is just outside the section line. This may be an older section of the forest. When Rev. Reiss (1889) wrote about his early exploration of the area he indicated a preference for Section 6 because of its timber. Some of these areas may have been able to become more mature forest because of protection against fire given by lakes and swamps.

Selective cutting of trees for timber has been part of St. John's history since the days when log cabins were built to validate their claims in 1864. Since then the local wood has been used for the beautifully carved woodwork and furniture in the older buildings and some of the furnishings in the new church (Reinhart, 1974). Some wood is still taken for fuel to "cook off" maple syrup and for use in fire places. Maple sap was collected every second year in three areas (Plots 2, 5, and 7). Some cutting of trees in these areas may have been done in building the tractor trails. Maple trees were saved for sap production. This continuous selection of mainly red and white oak for lumber and saving sugar maples for sap collection would over a period of time produce a forest with a higher index value. The oaks have greater difficulty reproducing in a climax forest and eventually there would be proportionally more shade tolerant trees. This is known as type conversion (Curtis, 1971).

Plots in Middle Continuum Index Range

Plots 1, 8, 10, and 12 were in the middle range of index values. Plot 12 is in the southern part of the forest. Plots 1 and 8 are in Section 31 and Plot 10 is just south of Section 31. Section 31 is the area described in the early history of St. John's woods as being fire damaged by Indians. The Indians may have used fire to keep the forest open and clear of underbrush. After doing library research on the historical use of fire in controlling vegetation, Stewart (1953) reported that burning of vegetation was a universal cultural pattern among the Indians of the United States. Among the reasons he lists for setting fires were to aid hunting, improve visibility, facilitate travel, and increase yield of berries, seeds and other wild foods.

Fire kindled by lightning in the fall or during a dry early spring could also have been a possibility. Oak leaves are especially flammable. They fall from the trees late; they curl and so have minimum contact with the soil; they resist matting and are slow to decompose. After a killing frost the herbaceous plants add to the flammable material as does dry dead wood (Brown and Davis, 1973).

Type of Succession

An interesting speculation could be made that succession in this forest was from a pine forest. Rev. Hoffman (1934) in writing about the early appearance of St. John's said, "The tallest trees found hereabout were pines. They are all gone I think. The tallest ones in the hollow behind the reservoir may have measured 60 feet. They have disappeared." Pines could have been overstory trees as found in several other places in central Minnesota such as Pine Grove in Little Falls and one stand in Granite Ledge Township in Benton County. Plants such as *Mitchella* and *Pyrola* present in the forest could be remnants from an association with pine trees. Species that achieve their maximum presence in boreal and northern dry mesic forests are found frequently in this forest. Some authors have written about this type of succession. Curtis (1971) states that a few of the xeric forests in southern Wisconsin may have been the result of progressive succession from relic stands of white and red pine. Buell and Cantlon (1951) presented evidence that the maple-basswood stand in Itasca Park succeeded a white pine-bur oak community. If there ever were extensive numbers of pines in the St. John's area, they must have been greatly reduced in number by the time the Benedictines came to this location. Pictures this author has seen of the early days of St. John's do not show evergreens.

More probably the forest has undergone a natural succession from a pioneer, xeric forest to a more mesic environment with succession based on shade tolerance, and soil improvement including increased moisture retention. Curtis (1971) states that trees typical of southern dry forests are bur oak, white oak, and black cherry. Trees common in a southern dry-mesic forest are red oak, large-toothed aspen, and red maple. In a southern mesic forest sugar maple, basswood, and ironwood are typical. Since all of these trees are present in varying proportions throughout St. John's forest it would seem that succession from dry to mesic conditions has been and is occurring.

Sapling Frequency

Sapling frequency gave an indication of the type of succession occurring in the forest. Of the major trees, only sugar maple showed greater sapling frequency than tree frequency (Table 6). Sugar maple becomes a dominant tree in southern mesic forests. Ironwood, June-berry, and blue beech also showed greater sapling frequencies than tree frequency. Ironwood by nature is a small tree and many of those of sapling size may be relatively old. Therefore the large number of ironwood saplings would not necessarily indicate increasing density. Juneberry is a small tree or shrub, infrequently found in tree size. Blue beech also is a small tree frequently found in the understory of hardwood forests (Collingwood and Bush, 1964).

The lower sapling frequencies of all the other species are indicative of lesser abilities to reproduce in a closed forest. All oak species had much lower sapling frequencies. Bur oak was the least shade tolerant of the oak species present in this study. Although bur oak saplings were rare in most of the forest, bur oak had a high frequency in Plot 3 (17.5%). After that area was cleared some bur oak seedlings survived to become sapling size, and some sprouts from stumps attained no more than sapling size in competition with other species. The aspens are pioneer trees that do not reproduce in shade. Birch is similar in habit, requiring an opening in the forest canopy for seedlings and saplings to survive. Basswood seedlings have difficulty becoming established in shade but the species is maintained by vegetative reproduction with shoots growing around the trunk of mature trees.

Understory Evidence for Southern Dry-Mesic Classification

Evidence for classifying this forest as southern dry-mesic is provided by the species of understory plants present as well as trees. Using the classification of plants by Curtis (1971) according to the type of community in which a species is modal or reaches its maximum presence, Table 19 lists the number of species in each plot modal to certain types of communities. Species modal to southern dry-mesic forests far outnumber others, averaging over 21 per study plot or 38.6 percent of the total number of species. The next highest were species modal in boreal forests averaging 7.5 species per plot or 13.6 percent of the total number.

Table 19. Number of Species Occurring in Plots Tabulated According to Type of Community in Which Species are Modal. Plots are arranged according to increasing continuum index values.

Community	Plot												Average
	3	4	9	12	10	8	1	7	6	5	2	11	
Southern Dry Forest	7	5	6	4	7	4	7	3	6	7	3	4	5.25
South. Dry-Mesic Forest	23	21	21	23	20	19	21	20	22	23	22	20	21.25
Southern Mesic Forest	3	6	5	6	5	5	6	4	4	6	5	5	5.00
South. Wet-Mesic Forest	4	3	2	2	2	2	2	4	2	3	1	3	2.50
Southern Wet Forest	2	2	2	1	1		1	2		2	1	1	1.25
Northern Dry Forest	2	2	1	2	1	1	1	2	3	2			1.42
North. Dry-Mesic Forest	6	5	6	5	5	5	5	7	5	6	6	3	5.33
Northern Mesic Forest	1	1	2	3	2	3	2	3	2	1	3	4	2.25
North. Wet-Mesic Forest		1	1			1						1	0.33
Boreal Forest	10	11	6	5	8	7	7	7	7	8	7	7	7.50
Oak Opening	1	1	1	1	1	1	1	1	1	1	1	1	1.00
Prairie Mesic	1	1		1					1				0.33
Prairie Wet-Mesic	1						1	1					0.25
Cedar Glade		1	2	1	1		1	1	1	1	1		0.83
Alder Thicket					1					1		1	0.25
Bracken-Grassland						1							0.08
Weed or Disturbed Area		1			1						1		0.25

When considering only the prevalent species (Table 8), eight (33%) of the 24 species with a f x p index over 500 were modal in southern dry-mesic forests. That was twice the number of prevalent species modal in any other type of community.

Since plants occur in their greatest frequency in the environment that is most favorable to them, St. John's forest would seem to be most favorable to southern dry-mesic species.

North and South Slopes

The frequencies of species on north and south slopes also showed relationships to community types. No bur oak or black cherry were found on north slopes; both species are more prevalent in southern dry forests. Bur oak is very tolerant of xeric conditions which would give it an advantage over other species pioneering on hot southern slopes (Curtis and McIntosh, 1951). The young black cherry has a high degree of shade tolerance, but needs more open pioneer conditions to mature into trees. Birch was found more frequently on northern slopes where conditions were more favorable for its growth. Birch is modal in northern dry-mesic forests, and St. John's forest is near the southern limits of its natural range.

South slopes had twice as many species modal to southern dry-mesic forests as did the north slopes. North slopes had more species modal to northern dry-mesic forests and boreal forests than did south slopes.

Plot 3

Plot 3 was a more pioneer area showing the retrogressive effects of being cut-over 50 years earlier. Its continuum index value was considerably lower than any other plot in the forest. Although Plot 3 had twice the number of tree trunks most of the plots had, the average basal area of the trunks was half the average basal area of the trunks found in the rest of the forest. The destruction of the canopy gave the pioneer trees, bur oak and the aspens, an opportunity to become established. The oaks produced second growth after cutting because of their great ability to sprout from stumps; mature maples were not capable of such regrowth (Curtis, 1971).

Understory plants typical of more pioneer communities (*Rosa* and *Crataegus*) had higher frequencies in this plot. *Zanthoxylum*, typically found in disturbed areas, reached its highest frequency in Plot 3.

Homogeneity

Although variations in the forest were evident, the St. John's forest had a high index of homogeneity, 83%. In Curtis' 1971 study of the plant communities of Wisconsin, the index of homogeneity for the forest communities ranged from 44.5 to 65.3. Curtis used stands of wide geographic range; this study used plots in one limited forest area which accounts for a high degree of homogeneity.

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APPENDIX I

Table 20. Importance Value of Trees in All Plots. * indicates highest importance value in plot. + indicates second highest importance value in plot. () denote highest importance value of species. Plots are listed in order of increasing continuum index values.

Species	Plot Number												Aver. I.V.
	3	4	9	12	10	8	1	7	6	5	2	11	
Quercus boreal.	120.5*	(161.2)*	146.1*	155.3*	123.4*	89.2*	144.0*	79.8*	80.2+	78.8+	55.7+	45.9	106.7
Acer saccharum	18.7	6.0	3.6	30.9	50.2	66.2+	60.5+	70.5+	91.3*	(90.4)*	88.6*	74.9*	54.3
Acer rubrum	17.6	27.5+	28.3+	33.8	55.5+	15.0	15.6	(68.2)	32.6	26.0	52.8	36.2	34.1
Ostrya virgin.	9.3	5.2	27.0	14.0	7.7	21.4	(36.5)	18.9	14.6	15.1	34.9	29.5	19.5
Tilia americana		20.5	6.9	39.8+	7.6	7.8	8.1	11.1	6.5	14.4	5.7	(56.4)+	15.4
Quercus alba	13.5	12.2	14.4	15.5	25.0	(29.2)	4.7	22.6	8.7	3.9	27.3	3.9	15.1
Ulmus americana	9.6	19.3	14.0	1.9	13.6	15.8	2.4	11.7	17.3	24.6	9.3	(39.7)	14.9
Betula papyrif.	6.0	14.5	12.2	4.5		17.4	15.7	2.6	(17.8)	7.2	10.3	2.9	9.3
Quercus macro.	(18.3)	9.6	18.3	1.6	4.2	7.6	4.4	7.5	1.8	8.0	13.7	2.3	8.1
Populus grand.	(37.4)	9.5	8.9	2.6	3.8	12.8		2.8	12.6	6.2			8.1
Populus tremul.	(42.0)+	7.2			3.2	2.2	1.8		9.0	15.8			6.8
Fraxinum penn.	5.1	5.7	(14.8)		5.9	10.9	6.1	4.2		6.7			5.0
Fraxinus nigra		1.7	1.9			(4.3)				3.0		1.6	1.0
Prunus serotina	2.0		1.8						(7.5)				0.9
Acer negundo												(6.5)	0.5
Carpinus carol.											(1.7)		0.1
Amelanchier sp.			(1.7)										0.1

Table 21. Average Basal Area (sq. in.) of Trees in All Plots. () denote the highest average basal area of species. Plots are listed in order of increasing continuum index values.

Species	Plot Number												Aver.
	3	4	9	12	10	8	1	7	6	5	2	11	B.A.
Quercus boreal.	56.7	137.1	126.3	187.4	154.9	135.5	177.5	186.0	123.2	170.8	(213.5)	178.9	148.0
Acer saccharum	22.1	113.7	33.6	(127.9)	43.1	54.6	43.5	117.0	66.5	51.7	86.2	62.1	73.8
Acer rubrum	20.2	45.3	38.1	48.4	79.5	42.2	48.4	64.6	63.7	45.7	74.7	(86.4)	60.4
Ostrya virgin.	15.1	15.3	16.9	18.1	(26.8)	17.5	21.5	15.8	18.2	23.6	19.9	20.8	19.5
Tilia americana		41.3	105.2	109.8	84.8	52.4	60.5	116.3	67.2	124.8	(219.3)	143.7	106.4
Quercus alba	28.2	92.8	187.0	76.1	103.0	115.9	114.6	138.0	(341.6)	108.4	85.6	134.6	108.4
Ulmus americana	69.7	50.5	58.8	64.6	53.0	90.9	114.9	65.9	104.7	(110.5)	48.8	133.5	87.7
Betula papyrif.	46.4	95.4	66.0	(144.2)		49.1	51.6	40.1	56.1	100.1	115.6	215.2	72.4
Quercus macro.	26.1	47.0	50.5	14.5	76.7	75.6	89.5	166.1	16.7	81.1	85.1	(114.9)	63.8
Populus grand.	43.6	76.8	94.0	(215.2)	48.4	69.5		(215.2)	57.3	101.5			67.0
Populus tremul.	52.7	127.5			74.0	81.5	21.7		71.3	(183.8)			80.7
Fraxinus penn.	61.9	43.3	55.6		(214.6)	93.3	59.4	92.3		73.9			77.6
Fraxinus nigra		11.5	(53.8)			27.1				47.1		12.4	31.6
Prunus serotin.	23.0		(35.3)						30.0				29.7
Acer negundo												(16.5)	16.5
Carpinus carol.											(16.7)		16.7
Amelanchier sp.			(17.9)										17.9
Average Basal Area of all Trees in Plot	44.7	101.7	89.0	134.4	100.0	78.7	94.8	110.1	78.7	89.1	110.8	94.9	93.9

Table 22. Frequency (%) of Trees in All Plots. () denote highest frequency of species. Plots are listed in order of increasing continuum index values.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Quercus boreal.	80.0	87.5	82.5	(97.5)	75.0	62.5	82.5	50.0	55.0	47.5	35.0	32.5	65.6
Acer saccharum	17.5	5.0	5.0	25.0	55.0	62.5	60.0	60.0	62.5	(72.5)	57.5	67.5	45.8
Acer rubrum	20.0	32.5	32.5	37.5	50.0	17.5	20.0	67.5	30.0	27.5	(52.5)	37.5	35.4
Ostrya virgini.	10.0	7.5	40.0	20.0	7.5	27.5	37.5	27.5	15.0	15.0	(42.5)	37.5	24.0
Tilia americana		25.0	7.5	45.0	7.5	10.0	10.0	12.5	7.5	12.5	5.0	(47.5)	15.8
Quercus alba	15.0	12.5	12.5	20.0	25.0	25.0	5.0	22.5	5.0	2.5	(27.5)	2.5	14.6
Ulmus americana	7.5	25.0	15.0	2.5	17.5	17.5	2.5	12.5	17.5	15.0	12.5	(35.0)	15.0
Betula papyrif.	5.0	15.0	15.0	5.0		(20.0)	17.5	2.5	(20.0)	7.5	10.0	2.5	10.0
Quercus macro.	(17.5)	12.5	22.5	2.5	5.0	7.5	5.0	7.5	2.5	7.5	12.5	2.5	8.8
Populus grand.	(30.0)	10.0	5.0	2.5	5.0	12.5		2.5	12.5	5.0			7.1
Populus tremul.	(25.0)	7.5			2.5	2.5	2.5		7.5	10.0			4.8
Fraxinus penn.	5.0	7.5	(15.0)		5.0	7.5	7.5	5.0		7.5			5.0
Fraxinus nigra		2.5	2.5			(5.0)				2.5		2.5	1.3
Prunus serotina	2.5		2.5						(10.0)				1.3
Acer negundo												(10.0)	0.8
Carpinus carol.											(2.5)		0.2
Amelanchier sp.			(2.5)										0.2

Table 23. Density of Trees in All Plots. () denote highest density of species. Plots are listed in order of increasing continuum index values.

Species	Plot Number												Aver. Density
	3	4	9	12	10	8	1	7	6	5	2	11	
Quercus boreal.	61	(86)	76	79	59	39	62	36	36	32	23	19	50.6
Acer saccharum	12	3	2	16	32	41	40	37	57	(60)	45	49	32.8
Acer rubrum	10	16	18	23	32	9	8	(43)	18	15	31	19	20.2
Ostrya virgini.	6	3	16	9	6	15	(28)	12	11	11	25	21	13.6
Tilia americana		12	3	20	4	4	4	5	3	6	2	(25)	7.3
Quercus alba	7	6	5	8	12	(13)	2	10	2	2	15	2	7.0
Ulmus americana	4	10	8	1	7	7	1	7	7	13	5	(18)	7.3
Betula papyrif.	3	7	6	2		(10)	9	2	9	3	5	1	4.8
Quercus macro.	(11)	5	10	1	2	4	2	3	1	4	8	1	4.3
Populus grand.	(20)	5	4	1	2	7		1	7	3			4.2
Populus tremul.	(23)	3			2	1	1		5	6			3.4
Fraxinus penn.	2	3	(9)		2	6	3	2		3			2.5
Fraxinus nigra		1	1			(3)				2		1	0.6
Prunus serotina	1		1						(4)				0.5
Acer negundo												(4)	0.3
Carpinus carol.											(1)		0.1
Amelanchier sp.			(1)										0.1

Table 24. Sapling Frequency in All Plots. () denote highest frequency of species. Plots are listed in order of increasing continuum index values.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Acer rubrum	(25.0)	15.0	10.0	12.5	17.5	17.5	2.5	20.0	17.5	10.0	10.0	2.5	13.3
Quercus macro.	(17.5)								2.5				1.7
Fraxinus penn.	(10.0)	2.5	2.5		2.5	7.5			2.5	2.5		2.5	2.7
Crataegus sp.	(5.0)												0.4
Prunus spp.	(5.0)		2.5										0.6
Betula papy.	2.5		2.5										0.4
Amelanchier spp.	7.5	(15.0)	12.5	5.0		2.5		10.0	12.5		2.5		5.6
Populus trem.		(2.5)											0.2
Ostrya virg.	70.0	90.0	(97.5)	90.0	72.5	85.0	92.5	80.0	60.0	50.0	87.5	62.5	78.1
Cornus alter.			(5.0)										0.4
Quercus borealis	2.5		(5.0)						2.5			(5.0)	1.3
Alnus sp.			(2.5)										7.5
Tilia americana		7.5	2.5	12.5	5.0	(17.5)	10.0	5.0	7.5	2.5	12.5	7.5	7.5
Carpinus carol.	(5.0)					(5.0)				2.5	2.5	2.5	1.5
Acer saccharum	62.5	32.0	7.5	65.0	70.0	65.0	60.0	67.5	(87.5)	82.5	62.5	(87.5)	62.5
Ulmus americana	10.0	15.0	7.5	2.5	10.0	10.0	10.0	7.5	2.5	(17.5)	7.5	15.0	9.6
Fraxinus nigra												(5.0)	0.4
Acer negundo												2.5	0.2

Table 25. Shrub and Vine Frequency in All Plots. () denote highest frequency of species. Plots are listed in order of increasing continuum index values.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Zanthoxylum	(47.5)	5.0	15.0	12.5	15.0	7.5	30.0		17.5	15.0	12.5	7.5	15.4
Vitis	(7.5)			2.5	2.5	5.0			2.5		2.5	5.0	2.3
Diervilla lon.	(5.0)	2.5			2.5								0.8
Rosa sp.	(2.5)												0.2
Crataegus sp.	(2.5)						(2.5)						0.4
Cornus alter.		(52.5)	20.0	47.5	5.0	27.5	15.0	20.0	12.5	25.0	7.5		19.4
Cornus race.	7.5	2.5	(10.0)		2.5		2.5			5.0			2.5
Rhus rad.		2.5	(5.0)	2.5			2.5	2.5			2.5		1.5
Juniperus sp.			(2.5)										0.2
Sambucus pub.				(2.5)								2.5	0.4
Prunus sp.	35.0	60.0	52.5	65.0	(87.5)	67.5	60.0	57.5	62.5	50.0	12.5	37.5	54.0
Lonicera dioica					(2.5)								0.2
Celastrus scan.			2.5	2.5		(5.0)							0.8
Dirca palustris						17.5	(70.0)	7.5			57.5	62.5	17.9
Amelanchier sp.	10.0	17.5	35.0	42.5	37.5	27.5	(50.0)	(50.0)	17.5	25.0	15.0	17.4	28.8
Viburnum Raf.	5.0	7.5	(17.5)	12.5	10.0	5.0	(17.5)	10.0	5.0	12.5	5.0	2.5	9.2
Hamamelis virg.								(2.5)					0.2
Parthenocissus	17.5	10.0	7.5	5.0	15.0	25.0	5.0	2.5	(20.0)	17.5	5.0	(20.0)	12.5
Symphoricarpus sp.		2.5		(5.0)	2.5	2.5		2.5	(5.0)	2.5		2.5	2.1
Ilex vert.		2.5						2.5		(5.0)			0.8
Ribes sp.	60.0	40.0	62.5	30.0	45.0	20.0	30.0	37.5	57.5	50.0	(72.5)	60.0	47.1
Rubus sp.	2.5	7.5	12.5	10.0	2.5	15.0	2.5	7.5	7.5	2.5	5.0	(17.5)	7.7

Table 26. Frequencies of Species Found in One Square Meter Plots. () denote highest frequency of species. P indicates species was present in area but did not occur in samples.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Geranium mac.	(35.0)	20.0	10.0		12.5	10.0	5.0	7.5	5.0	12.5	20.0	P	11.5
Zanthoxylum am.	(25.0)	2.5	5.0	2.5	2.5	5.0	7.5		2.5	10.0	P	2.5	5.0
Parthenocissus	(17.5)	5.0	P	P	5.0	5.0	5.0	P	15.0	12.5	P	5.0	5.8
Quercus macro.	(5.0)	P	P	P	P	P	P	P	P	P	P	P	0.4
Rhus radicans	(5.0)	(5.0)	P	P			2.5	P		P	P		1.0
Rosa sp.	(5.0)	P		P					P				0.4
Menispermum can.	(5.0)												0.4
Agrimonia sp.	(5.0)								P				0.4
Arenaria later.	(2.5)												0.2
Carpinus carol.	(2.5)	P				P				P	P	P	0.2
Cicuta maculata	(2.5)							P					0.2
Luzula acum.	(2.5)												0.2
Osmorhiza long.	(2.5)									P			0.2
Viburnum lent.	(2.5)		P										0.2
Celastrus scan.	P		P	P		P							-
Crataegus sp.	P						P						-
Urtica dioica	P							P					-
Viola spp.	32.5	(45.0)	15.0	5.0	12.5	15.0	22.5	20.0	32.5	22.5	27.5	17.5	22.3
Cornus alter	P	(25.0)	P	5.0	P	P	2.5	2.5	2.5	2.5	2.5		3.5
Ribes Cynosbati	15.0	(17.5)	20.0	2.5	2.5	P	7.5	15.0	P	5.0	7.5	P	7.7
Rubus spp.	5.0	(10.0)	P	2.5	2.5	5.0	2.5	7.5	5.0	2.5	2.5	7.5	3.5
Aralia race.	P	(2.5)		P		P			P				0.2
Diervilla lon.	P	P			P								-
Aster macro.	10.0	37.5	(60.0)	17.5	10.0	20.0	32.5	7.5	7.5	10.0	12.5	2.5	19.0
Amphicarpa bra.	30.0	32.5	(55.0)	7.5	10.0	20.0	2.5	7.5	17.5	15.5	15.0	P	17.7

Table 26. Continued.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Circaea quad.	30.0	25.0	(45.0)	10.0	10.0	25.0	7.5	15.0	15.0	17.5	37.5	27.5	22.1
Galium triflorum	5.0	2.5	(30.0)	5.0	5.0	20.0	P	25.0	5.0	15.0	17.5	7.5	11.5
Tilia americana		2.5	(20.0)	P	2.5	15.0	2.5	15.0	2.5	5.0	10.0	5.0	6.7
Solidago flexi.	2.5	15.0	(25.0)	15.0	2.5	15.0	22.5	2.5	20.0	2.5	2.5	15.0	11.7
Maianthemum can.	2.5	2.5	(15.0)		2.5		5.0	2.5	P	10.0	7.5		4.0
Thalictrum dioicum			(15.0)				5.0				P	10.0	2.5
Cornus racemosa	5.0	2.5	(10.0)		P		P			P			1.5
Monotropa uniflora	P		(5.0)	P	2.5								0.6
Populus grand.	(5.0)	2.5	(5.0)	P	P	(5.0)		2.5	2.5	P			1.9
Smilax herbacea	2.5	P	(5.0)		P		2.5		P	P		2.5	1.0
Pea - unknown			(5.0)				2.5	2.5	2.5				1.0
Ranunculus abort.			(5.0)										0.4
Juniperus sp.			P										-
Monarda fistula			P										-
Solidago sp.			P										-
Vicia caroliniana			P										-
Alnus sp.			P										-
Betula papyrifera	7.5	P	(10.0)	(10.0)		P	P	5.0	P	2.5	5.0	P	3.3
Desmodium nud.	2.5	7.5	(10.0)	(10.0)	5.0	5.0	2.5		2.5	P	7.5	2.5	4.6
Sanicula greg.	P	5.0	(10.0)	(10.0)	2.5		2.5			P	P		2.5
Aquilegia canad.		(2.5)	P	(2.5)	P		P	P	(2.5)	(2.5)	P		0.8
Pinus (seedling)				(2.5)									0.2
Quercus alba	P	P	P	(2.5)	P	P	P	P	P	P	P	P	0.2
Corallorhiza sp.		P		P			P						-
Oryzopsis asper.	32.5	12.5	10.0	15.0	(37.5)	15.0	10.0	22.5	32.5	7.5	10.0	20.0	18.7
Prunus spp.	22.5	22.5	25.0	7.5	(27.5)	25.0	15.0	7.5	22.5	17.5	5.0	7.5	17.1
Laportea canad.		2.5	5.0		(7.5)			2.5		(7.5)			2.1

Table 26. Continued.

Species	Plot Number 3	4	9	12	10	8	1	7	6	5	2	11	Aver. Freq.
Oryzopsis race.		2.5	P	P	(5.0)	P	2.5	P	2.5	2.5			1.3
Actaea rubra		P	P	(2.5)	(2.5)	P			P		P	P	
Viburnum raf.	2.5	2.5	P	P	(2.5)	P	P	P	2.5	P	P	2.5	1.0
Chenopodium hyb.					P								-
Lonicera dioica					P								-
Oxalis sp.					P								-
Quercus borealis	12.5	10.0	20.0	17.5	20.0	(40.0)	12.5	32.5	27.5	27.5	P	5.0	18.7
Pyrola spp.	P	5.0	5.0	12.5	P	(15.0)		2.5	2.5	5.0	P		4.0
Asplenium sp.	7.5	7.5	(10.0)	5.0	P	(10.0)	2.5	7.5	7.5	(10.0)	5.0	2.5	6.2
Symphoricarpus sp.		2.5		P	2.5	(10.0)		2.5	5.0	P		P	1.9
Trillium cernuum	5.0	2.5	P			(10.0)			P	P		P	1.5
Bidens sp.						(5.0)							0.4
Caulophyllum thal.	P	2.5	(5.0)	P	2.5	(5.0)	2.5			P	2.5	P	1.7
Geum canadense	(5.0)	2.5			(5.0)	(5.0)		P	2.5	2.5	2.5		2.1
Helianthus sp.						(5.0)							0.4
Lycopus sp.						(5.0)							0.4
Pilea sp.						(5.0)							0.4
Vitis sp.	2.5	P	P	P	P	(5.0)		P	P		P	P	0.6
Euonymus atro.						(5.0)							0.4
Cypripedium cal.				P		P	P						-
Pteridium aquilinum						P							-
Ulmus americana	5.0	7.5	5.0	2.5	5.0	10.0	(17.5)	7.5	5.0	7.5	12.5	10.0	7.9
Smilacina racemosa	2.5	5.0	(20.0)	P	2.5	5.0	(20.0)	10.0	7.5	10.0	2.5	7.5	7.7
Sanguinaria canad.		5.0		7.5			(10.0)			2.5			2.1
Habenaria sp.							P						-
Orchis spect.							P						-
Veronicastrum virg.							P						-

Table 26. Continued.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Acer rubrum	20.0	37.5	55.0	20.0	37.5	20.0	25.0	(70.0)	17.5	37.5	27.5	27.5	32.9
Ostrya virg.	22.5	40.0	30.0	20.0	32.5	40.0	30.0	(47.5)	30.0	27.5	17.5	32.5	30.8
Uvularia sessil.	2.5	12.5	5.0	7.5	2.5	15.0	12.5	(22.5)	20.0	20.0	15.0		11.2
Trientalis bor.	7.5	2.5		P			2.5	(7.5)		2.5			1.9
Botrychium virg.	2.5	2.5		2.5	P		P	(5.0)	2.5	P	P	2.5	1.5
Mitchella repens								(5.0)			P		0.4
Anemonella thal.								(2.5)					0.2
Brachyelytrum ere.			P	P	P		P	(2.5)	P	P	P	(2.5)	0.4
Goodyera pubescens	P	P		P		P	P	(2.5)		P			0.2
Hamamelis virg.								(2.5)					0.2
Panax quinq.				P				(2.5)	P	P	P		0.2
Erigeron sp.								P					-
Ilex verticillata		P						P		P			-
Carex spp.	62.5	45.0	50.0	37.5	55.0	60.0	47.5	62.5	(80.0)	45.0	40.0	30.0	51.2
Uvularia grand.	P	5.0	P	P	2.5	25.0	10.0	7.5	(37.5)	22.5	7.5	7.5	10.4
Smilacina stellata	P		5.0		2.5		P		(7.5)	2.5	P		1.5
Fragaria virg.		(2.5)		P			P	(2.5)	(2.5)	(2.5)			0.8
Hystrix patula				P	(2.5)				(2.5)			(2.5)	0.6
Osmunda clayton.	(2.5)			P				P	(2.5)			(2.5)	0.6
Triosteum perf.						P			(2.5)				0.2
Osmorhiza claytoni	27.5	40.0	35.0	17.5	20.0	25.0	15.0	22.5	17.5	(65.0)	22.5	37.5	28.7
Aralia nudic.	2.5	25.0	25.0	7.5	7.5	20.0	15.0	17.5	15.0	(30.0)	5.0	P	14.2
Polygonatum pub.	12.5	12.5	P	10.0	7.5	15.0	5.0	17.5	7.5	(20.0)	12.5	P	10.0
Arisaema triphyllum		2.5				5.0		2.5		(12.5)		P	1.9
Amelanchier sp.	2.5	7.5	5.0	5.0	2.5	P	2.5	2.5	2.5	(10.0)	2.5	P	3.5
Populus trem.	7.5	P			P	P	P	2.5	5.0	(10.0)			2.1
Cryptotaenia canad.	P	P		2.5	2.5		P			(5.0)	P	2.5	1.0

Table 26. Continued.

Species	Plot Number												Aver. Freq.
	3	4	9	12	10	8	1	7	6	5	2	11	
Cynoglossum bor.	(2.5)								P	(2.5)			0.4
Onoclea sensibilis					P					(2.5)		P	0.2
Festuca obtusa										(2.5)			0.2
Acer sacc.	5.0	5.0	P	52.5	45.0	55.0	75.0	70.0	65.0	75.0	(87.5)	52.5	48.9
Hepatica amer.		P			P		12.5	30.0			(32.5)	12.5	7.3
Anemone quinq.	12.5	17.5	5.0		P	5.0	17.5	5.0	7.5	10.0	(25.0)		8.7
Milium effusum			5.0	2.5	5.0	5.0		2.5	2.5		(7.5)	2.5	2.7
Ranunculus abort.			5.0							2.5	(7.5)		1.2
Impatiens sp.										2.5	(5.0)	P	0.6
Taraxacum off.		2.5									(5.0)		0.6
Sedge - unknown											(7.5)		0.6
Fraxinus penn.	P	2.5	10.0	10.0	2.5	10.0	2.5	P	10.0	15.0		25.0	7.3
Dirca palustris						10.0	5.0	P			P	(12.5)	2.3
Phryma lepto.	2.5	7.5	5.0	5.0	5.0	5.0	7.5	2.5	P	7.5	10.0	(12.5)	5.8
Aster sp.			P		P		2.5		P		2.5	(7.5)	1.0
Eupatorium rugosum			P								2.5	(5.0)	0.6
Fern - unknown												(5.0)	0.4
Adiantum ped.												(2.5)	0.2
Fraxinus nigra		P	P			P				P		(2.5)	0.2
Sambucus pubens				P								(2.5)	0.2
Acer negundo												P	

APPENDIX II

Table 27. Summary of Tree Data for Plot 1.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	177.5	11003.0	72.6	82.5	33.0	62	38.7	144.3	793.7
Acer sacc.	43.5	1741.4	11.5	60.0	24.0	40	25.0	60.5	604.8
Acer rubrum	48.4	387.4	2.6	20.0	8.0	8	5.0	15.6	108.9
Ostrya virg.	21.5	601.6	4.0	37.5	15.0	28	17.5	36.5	301.0
Tilia amer.	60.5	242.0	1.6	10.0	4.0	4	2.5	8.1	60.7
Ulmus amer.	114.9	114.9	0.8	2.5	1.0	1	0.6	2.4	17.9
Quercus alba	114.6	229.1	1.5	5.0	2.0	2	1.2	4.8	16.7
Betula papy.	51.6	464.4	3.1	17.5	7.0	9	5.6	15.7	78.4
Quercus mac.	89.5	179.0	1.2	5.0	2.0	2	1.2	4.4	4.4
Fraxinus penn.	59.4	178.3	1.2	7.5	3.0	3	1.9	6.1	39.4
Populus trem.	21.7	21.7	0.1	2.5	1.0	1	0.6	1.8	1.8
					Total I.V. or Continuum Index				2036.8

Table 28. Summary of Tree Data for Plot 2.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	213.5	4910.3	27.7	35.0	13.6	23	14.4	55.7	306.2
Acer sacc.	86.2	6751.4	38.1	57.5	22.3	45	28.1	88.6	885.5
Acer rubrum	74.7	2316.2	13.1	52.5	20.4	31	19.4	52.8	369.9
Ostrya virg.	19.9	498.3	2.8	42.5	16.4	25	15.6	34.9	296.9
Tilia amer.	219.3	438.7	2.5	5.0	1.9	2	1.3	5.7	42.4
Quercus alba	85.6	1284.0	7.2	27.5	10.7	15	9.4	27.3	95.5
Ulmus amer.	48.8	244.3	1.4	12.5	4.8	5	3.1	9.3	70.1
Betula papy.	115.6	578.2	3.3	10.0	3.9	5	3.1	10.3	51.3
Quercus mac.	85.8	686.5	3.9	12.5	4.8	8	5.0	13.7	13.7
Carpinus carol.	16.7	16.7	0.1	2.5	1.0	1	0.6	1.7	13.4
					Total I.V. or Continuum Index				2145.1

Table 29. Summary of Tree Data for Plot 3.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	56.7	3458.6	48.4	80.0	34.0	61	38.1	120.5	662.9
Acer sacc.	22.1	265.5	3.7	17.5	7.4	12	7.5	18.7	186.6
Acer rubrum	20.2	202.2	2.8	20.0	8.5	10	6.2	17.6	123.1
Ostrya virg.	15.1	90.6	1.3	10.0	4.3	6	3.7	9.3	78.9
Quercus alba	28.2	197.5	2.8	15.0	6.4	7	4.4	13.5	47.3
Ulmus amer.	69.7	278.9	3.9	7.5	3.2	4	2.5	9.6	71.9
Betula papy.	46.4	139.2	1.9	5.0	2.1	3	1.9	6.0	29.8
Quercus mac.	26.1	286.8	4.0	17.5	7.4	11	6.9	18.3	18.3
Populus grand.	43.6	871.4	12.2	30.0	12.8	20	12.5	37.4	168.5
Populus trem.	52.8	1213.8	17.0	25.0	10.6	23	14.4	42.0	42.0
Fraxinus penn.	61.9	123.8	1.7	5.0	2.1	2	1.2	5.1	33.2
Prunus ser.	23.0	23.0	0.3	2.5	1.1	1	0.6	2.0	7.0
					Total I.V. or Continuum Index				1469.6

Table 30. Summary of Tree Data for Plot 4.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	137.1	11792.8	72.5	87.5	35.0	86	53.7	161.2	886.7
Acer sacc.	113.7	341.2	2.1	5.0	2.0	3	1.9	6.0	60.0
Acer rubrum	45.2	724.1	4.4	32.5	13.0	16	10.0	27.4	192.1
Ostrya virg.	15.2	45.8	0.3	7.5	3.0	3	1.9	5.2	43.9
Tilia amer.	41.3	495.7	3.0	25.0	10.0	12	7.5	20.6	154.1
Quercus alba	92.8	557.0	3.4	12.5	5.0	6	3.7	12.2	42.6
Ulmus amer.	50.5	504.6	3.1	25.0	10.0	10	6.2	19.3	145.1
Betula papy.	95.4	667.6	4.1	15.0	6.0	7	4.4	14.5	72.4
Quercus mac.	47.0	235.2	1.4	12.5	5.0	5	3.1	9.6	9.6
Populus grand.	76.8	384.2	2.4	10.0	4.0	5	3.1	9.5	42.7
Populus trem.	127.5	382.6	2.3	7.5	3.0	3	1.9	7.2	7.2
Fraxinus penn.	43.3	129.9	0.8	7.5	3.0	3	1.9	5.7	36.9
Fraxinus nigra	11.5	11.5	0.1	2.5	1.0	1	0.6	1.7	10.1
					Total I.V. or Continuum Index				1703.4

Table 31. Summary of Tree Data for Plot 5.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	170.8	5465.7	38.3	47.5	20.4	32	20.0	78.8	433.2
Acer sacc.	51.7	3100.3	21.7	72.5	31.2	60	37.5	90.4	904.2
Acer rubrum	45.7	685.5	4.8	27.5	11.8	15	9.4	26.0	182.1
Ostrya virg.	23.6	259.2	1.8	15.0	6.4	11	6.9	15.1	128.7
Tilia amer.	124.8	748.9	5.2	12.5	5.4	6	3.7	14.4	107.8
Quercus alba	108.4	216.8	1.5	2.5	1.1	2	1.2	3.8	13.5
Ulmus amer.	110.5	1437.1	10.1	15.0	6.4	13	8.1	24.6	184.9
Betula papy.	100.1	300.2	2.1	7.5	3.2	3	1.9	7.2	36.1
Quercus mac.	81.1	324.4	2.3	7.5	3.2	4	2.5	8.0	8.0
Populus grand.	101.5	304.5	2.1	5.0	2.1	3	1.9	6.1	27.7
Populus trem.	183.8	1102.7	7.7	10.0	4.3	6	3.7	15.8	15.8
Fraxinus penn.	73.9	221.7	1.6	7.5	3.2	3	1.9	6.7	43.3
Fraxinus nigra	47.1	94.2	0.7	2.5	1.1	2	1.2	3.0	17.9
					Total I.V. or Continuum Index				2103.3

Table 32. Summary of Tree Data for Plot 6.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	123.1	4433.4	35.2	55.0	22.4	36	22.5	80.2	440.9
Acer sacc.	66.5	3789.7	30.1	62.5	25.5	57	35.6	91.2	912.5
Acer rubrum	63.7	1146.7	9.1	30.0	12.2	18	11.2	32.6	228.2
Ostrya virg.	18.2	199.7	1.6	15.0	6.1	11	6.9	14.6	124.0
Tilia amer.	67.2	201.6	1.6	7.5	3.1	3	1.9	6.5	49.1
Quercus alba	341.6	683.2	5.4	5.0	2.0	2	1.2	8.7	30.5
Ulmus amer.	104.7	732.9	5.8	17.5	7.1	7	4.4	17.3	130.0
Betula papy.	56.1	504.7	4.0	20.0	8.2	9	5.6	17.8	88.9
Quercus mac.	16.7	16.7	0.1	2.5	1.0	1	0.6	1.8	1.8
Populus grand.	57.3	401.2	3.2	12.5	5.1	7	4.4	12.7	57.0
Populus trem.	71.3	356.7	2.8	7.5	3.1	5	3.1	9.0	9.0
Prunus ser.	30.0	119.9	0.9	10.0	4.1	4	2.5	7.5	26.4
					Total I.V. or Continuum Index				2098.3

Table 33. Summary of Tree Data for Plot 7.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	186.0	6696.1	38.5	50.0	18.5	36	22.8	79.8	438.9
Acer sacc.	116.9	4327.3	24.9	60.0	22.2	37	23.4	70.5	705.2
Acer rubrum	64.6	2776.6	16.0	67.5	25.0	43	27.2	68.2	477.3
Ostrya virg.	15.8	189.1	1.1	27.5	10.2	12	7.6	18.9	160.4
Tilia amer.	116.3	581.3	3.3	12.5	4.6	5	3.2	11.1	83.5
Quercus alba	138.0	1380.3	7.9	22.5	8.3	10	6.3	22.6	79.1
Ulmus amer.	65.9	461.2	2.6	12.5	4.6	7	4.4	11.7	87.8
Betula papy.	40.1	80.3	0.5	2.5	0.9	2	1.3	2.6	13.2
Quercus mac.	166.1	498.2	2.9	7.5	2.8	3	1.9	7.6	7.6
Populus grand.	215.1	215.1	1.2	2.5	0.9	1	0.6	2.8	12.6
Fraxinus penn.	92.3	184.6	1.1	5.0	1.9	2	1.3	4.2	27.2
					Total I.V. or Continuum Index				2092.8

Table 34. Summary of Tree Data for Plot 8.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	135.5	5282.8	42.2	62.5	22.5	39	24.5	89.2	490.8
Acer sacc.	54.6	2238.2	17.9	62.5	22.5	41	25.8	66.2	661.9
Acer rubrum	42.2	380.2	3.0	17.5	6.3	9	5.7	15.0	105.1
Ostrya virg.	17.5	262.9	2.1	27.5	9.9	15	9.4	21.4	182.2
Tilia amer.	52.4	209.6	1.7	10.0	3.6	4	2.5	7.8	58.4
Quercus alba	115.9	1506.9	12.0	25.0	9.0	13	8.2	29.2	102.3
Ulmus amer.	90.9	636.1	5.1	17.5	6.3	7	4.4	15.8	118.4
Betula papy.	49.1	491.2	3.9	20.0	7.2	10	6.3	17.4	87.1
Quercus mac.	75.6	302.5	2.4	7.5	2.7	4	2.5	7.6	7.6
Populus grand.	69.5	486.5	3.9	12.5	4.5	7	4.4	12.8	57.6
Populus trem.	81.5	81.5	0.6	2.5	0.9	1	0.6	2.2	2.2
Fraxinus penn.	93.3	560.0	4.5	7.5	2.7	6	3.8	10.9	71.1
Fraxinus nigra	27.0	81.2	0.6	5.0	1.8	3	1.9	4.3	26.0
					Total I.V. or Continuum Index				1970.8

Table 35. Summary of Tree Data for Plot 9.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	126.3	9601.3	67.5	82.5	31.1	76	47.5	146.1	803.5
Acer sacc.	33.5	67.1	0.5	5.0	1.9	2	1.2	3.6	36.1
Acer rubrum	38.3	689.5	4.8	32.5	12.3	18	11.2	28.3	198.4
Ostrya virg.	16.9	270.1	1.9	40.0	15.1	16	10.0	27.0	229.4
Tilia amer.	105.2	315.7	2.2	7.5	2.8	3	1.9	6.9	51.9
Quercus alba	187.0	935.1	6.6	12.5	4.7	5	3.1	14.4	50.5
Ulmus amer.	58.8	470.5	3.3	15.0	5.7	8	5.0	14.0	104.8
Betula papy.	66.0	396.2	2.8	15.0	5.7	6	3.7	12.2	60.9
Quercus mac.	50.5	504.7	3.5	22.5	8.5	10	6.2	18.3	18.3
Populus grand.	94.0	376.2	2.6	10.0	3.8	4	2.5	8.9	40.1
Fraxinus penn.	55.6	500.0	3.5	15.0	5.7	9	5.6	14.8	96.1
Fraxinus nigra	53.8	53.8	0.4	2.5	0.9	1	0.6	1.9	11.7
Prunus ser.	35.3	35.3	0.2	2.5	0.9	1	0.6	1.8	6.4
Amelanchier sp.	17.9	17.9	0.1	2.5	0.9	1	0.6	1.7	1.7
					Total I.V. or Continuum Index				1709.9

Table 36. Summary of Tree Data for Plot 10.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	154.9	9138.0	57.1	75.0	29.4	59	36.9	123.4	678.8
Acer sacc.	43.1	1377.9	8.6	55.0	21.6	32	20.0	50.2	501.8
Acer rubrum	79.5	2545.2	15.9	50.0	19.6	32	20.0	55.5	388.6
Ostrya virg.	26.8	160.8	1.0	7.5	2.9	6	3.7	7.7	65.4
Tilia amer.	84.8	339.2	2.1	7.5	2.9	4	2.5	7.6	56.7
Quercus alba	103.0	1236.3	7.7	25.0	9.8	12	7.5	25.0	87.6
Ulmus amer.	53.0	371.1	2.3	17.5	6.9	7	4.4	13.6	101.7
Quercus mac.	76.7	153.4	1.0	5.0	2.0	2	1.2	4.2	4.2
Populus grand.	48.4	96.8	0.6	5.0	2.0	2	1.2	3.8	17.2
Populus trem.	74.0	148.1	1.0	2.5	1.0	2	1.2	3.2	3.2
Fraxinus penn.	214.6	429.3	2.7	5.0	2.0	2	1.2	5.9	38.3
					Total I.V. or Continuum Index				1943.5

Table 37. Summary of Tree Data for Plot 11.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	178.9	3400.0	22.4	32.5	11.7	19	11.9	45.9	252.7
Acer sacc.	62.0	3040.4	20.0	67.5	24.3	49	30.6	75.0	749.7
Acer rubrum	86.4	1641.0	10.8	37.5	13.5	19	11.9	36.2	253.3
Ostrya virg.	20.8	436.8	2.9	37.5	13.5	21	13.1	29.5	250.8
Tilia amer.	143.6	3591.1	23.6	47.5	17.2	25	15.6	56.4	422.9
Quercus alba	134.6	269.1	1.8	2.5	0.9	2	1.2	3.9	13.7
Ulmus amer.	133.5	2403.1	15.8	35.0	12.6	18	11.2	39.7	297.6
Betula papy.	215.1	215.1	1.4	2.5	0.9	1	0.6	2.9	14.7
Quercus mac.	114.9	114.9	0.8	2.5	0.9	1	0.6	2.3	2.3
Fraxinus nigra	12.4	12.4	0.1	2.5	0.9	1	0.6	1.6	9.7
Acer negundo	16.5	66.1	0.4	10.0	3.6	4	2.5	6.5	6.5
					Total I.V. or Continuum Index				2274.0

Table 38. Summary of Tree Data for Plot 12.

Species	Average B.A./tree (sq. in.)	Dominance (sq. in.)	Relative Dom. (%)	Frequency (%)	Relative Freq. (%)	Density	Relative Den. (%)	I.V.	Weighted I.V.
Quercus bor.	187.4	14801.4	68.8	97.5	37.1	79	49.4	155.3	854.3
Acer sacc.	127.9	2045.8	9.5	25.0	11.4	16	10.0	30.9	309.4
Acer rubrum.	48.4	1113.7	5.2	37.5	14.3	23	14.4	33.8	236.9
Ostrya virg.	18.1	162.6	0.8	20.0	7.6	9	5.6	14.0	119.1
Tilia amer.	109.8	2196.4	10.2	45.0	17.1	20	12.5	39.8	298.9
Quercus alba	76.1	608.5	2.8	20.0	7.6	8	5.0	15.4	54.1
Ulmus amer.	64.6	64.6	0.3	2.5	0.9	1	0.6	1.9	14.0
Betula papy.	144.2	288.5	1.3	5.0	1.9	2	1.2	4.5	22.4
Quercus mac.	14.5	14.5	0.1	2.5	0.9	1	0.6	1.6	1.6
Populus grand.	215.1	215.1	1.0	2.5	0.9	1	0.6	2.6	11.6
					Total I.V. or Continuum Index				1922.4